Connected Vehicle Pilot Deployment Workshop 2014

Kate Hartman
USDOT Intelligent Transportation Systems
Program Manager, CV Pilot Deployment Program

30 April 2014



Workshop Purpose

- Set the vision for the connected vehicle pilot deployment program
- Inform stakeholders on the resources available to assist in the successful planning and execution of pilot deployments
- Motivate participation in the pilot deployment program among public sector agencies, industry and the research community
- Capture stakeholder feedback and adapt our plans as appropriate

Welcome

Ken Leonard
USDOT Intelligent Transportation Systems
Joint Program Office Director

Workshop Agenda

Session	Title/Speaker	Time
1	Connected Vehicle Research Program Brian Cronin, ITS JPO	8:45 - 9:15 AM
2	Connected Vehicle Pilot Deployment Program Kate Hartman, ITS JPO	9:15 - 9:45 AM
3	Creating CV Pilot Deployment Concepts Panel Moderator: Jeff Spencer, FTA	10:00 AM - Noon
4	CV Pilot Request for Information Summary Kate Hartman, ITS JPO	1:00 - 1:30 PM
5	Breakout Sessions (Round 1) Breakout Sessions (Round 2)	1:45 - 2:45 PM 3:00 - 4:00 PM
6	Breakout Reports	4:15 - 5:00 PM

Connected Vehicle Research Program Overview

Brian Cronin
USDOT ITS JPO
Team Leader, ITS Research and Demonstration



Connected Vehicle Research Program Overview

- Introduction to the USDOT Connected Vehicle Research Program
- Program Products
 - Applications Research and Development
 - Enabling Technologies Research
 - Reference Implementation Architecture
 - Standards Development
 - Affiliated Test Beds
 - Research Data Exchange (RDE)
- Key Research Findings
 - Why we think the timing is right for an opportunity to move research products into operational practice

Transportation Challenges



Safety

33,561 highway deaths in 2012 5,615,000 crashes in 2012 Leading cause of death for ages 4, 11-27





Mobility

5.5 billion hours of travel delay\$121 billion cost of urban congestion



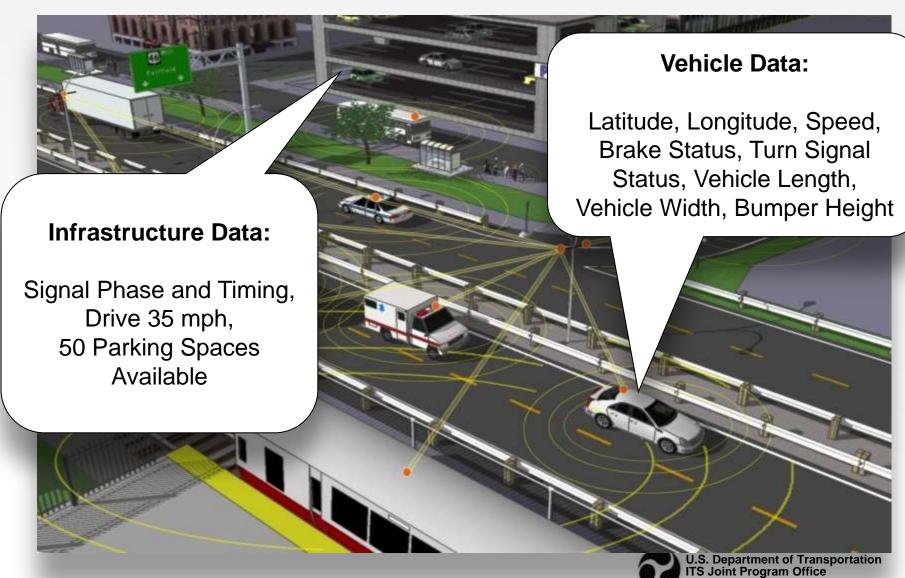


Environment

2.9 billion gallons of wasted fuel 56 billion lbs. of additional CO₂



Connected Vehicles

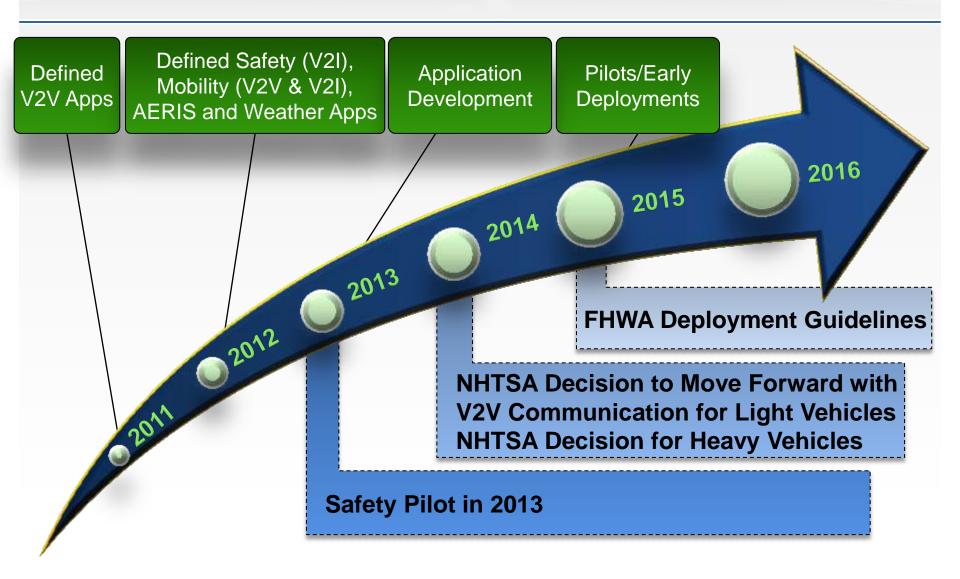


Connected Vehicle Communications Technology

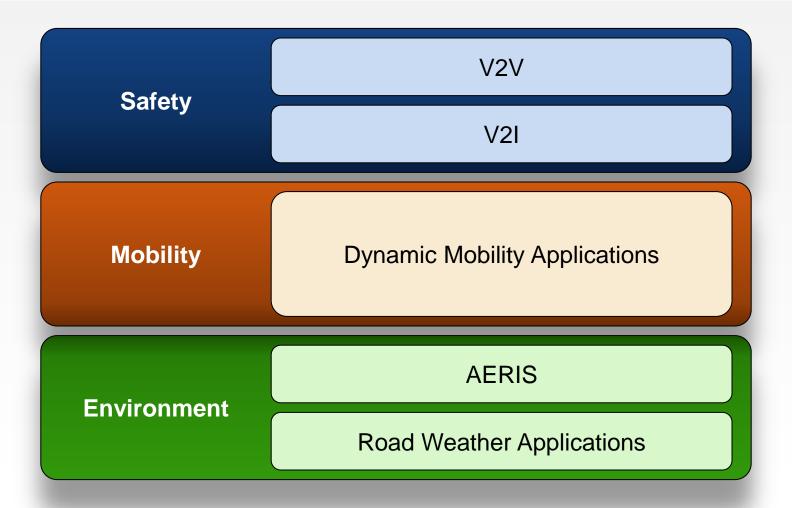
- 5.9 GHz DSRC
- 4G and older 3G cellular networks provide high-bandwidth data communications
- Other wireless technologies such as Wi-Fi, satellite, and HD radio may have roles to play



Path to Deployment



Connected Vehicle Application Research and Development Programs



Connected Vehicle Applications

- The USDOT has made a significant investment in foundational research and initial development of connected vehicle applications
 - Concepts of Operations
 - System Requirements
 - Prototype Design and Testing
 - Prototype Impacts Assessment
 - Analytics, Modeling and Simulation to Assess Potential Long-Term Impacts
- Not all CV Application efforts are in the same state of maturity, few are complete
 - But a large number of application development efforts across multiple programs will be substantively complete in late 2014

Connected Vehicle Applications

Please see your handout

V2I Safety

Red Light Violation Warning
Curve Speed Warning
Stop Sign Gap Assist
Spot Weather Impact Warning
Reduced Speed/Work Zone Warning
Pedestrian in Signalized Crosswalk
Warning (Transit)

V2V Safety

Emergency Electronic Brake Lights (EEBL)
Forward Collision Warning (FCW)
Intersection Movement Assist (IMA)
Left Turn Assist (LTA)
Blind Spot/Lane Change Warning
(BSW/LCW)
Do Not Pass Warning (DNPW)
Vehicle Turning Right in Front of Bus
Warning (Transit)

Road Weather

Motorist Advisories and Warnings (MAW) Enhanced MDSS Vehicle Data Translator (VDT) Weather Response Traffic Information

(WxTINFO)

Environment

Eco-Approach and Departure at Signalized Intersections **Eco-Traffic Signal Timing Eco-Traffic Signal Priority** Connected Eco-Driving Wireless Inductive/Resonance Charging **Eco-Lanes Management Eco-Speed Harmonization Eco-Cooperative Adaptive Cruise Control Eco-Traveler Information Eco-Ramp Metering** Low Emissions Zone Management AFV Charging / Fueling Information **Eco-Smart Parking** Dynamic Eco-Routing (light vehicle, transit, freight) **Eco-ICM Decision Support System**

Agency Data

Probe-based Pavement Maintenance
Probe-enabled Traffic Monitoring
Vehicle Classification-based Traffic
Studies
CV-enabled Turning Movement &
Intersection Analysis
CV-enabled Origin-Destination Studies
Work Zone Traveler Information

Mobility

Advanced Traveler Information System Intelligent Traffic Signal System (I-SIG)
Signal Priority (transit, freight)

Mobile Accessible Pedestrian Signal System (PED-SIG)

Emergency Vehicle Preemption (PREEMPT)
Dynamic Speed Harmonization (SPD-HARM)
Queue Warning (Q-WARN)

Cooperative Adaptive Cruise Control (CACC) Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG) Incident Scene Work Zone Alerts for Drivers

and Workers (INC-ZONE)

Emergency Communications and Evacuation (EVAC)

Connection Protection (T-CONNECT)

Dynamic Transit Operations (T-DISP)

Dynamic Ridesharing (D-RIDE)

Freight-Specific Dynamic Travel Planning and Performance

Drayage Optimization

Smart Roadside

Wireless Inspection Smart Truck Parking



Open Source Application Development Portal

www.itsforge.net



- Portal for sharing documentation and source code from USDOTsponsored application prototyping efforts
- By end of 2014, will be populated with materials describing 20+ connected vehicle applications
- Contributed code must meet documentation guidelines
- Search and download functions
- In prototype form now
 - Enhanced Release 1 expected summer 2014

Enabling Technologies:Roadside Equipment for Connected Vehicles

Equipment

USDOT tested devices for placement on the Research Qualified Products List (RQPL).

Five vendors of connected vehicle roadside equipment are currently on the list. Devices are based on RSE Specification v3.0.

Roadside Unit (RSU) Specification v4.0 will be available spring 2014. It contains updates to the physical hardware, management information base (MIB), and firmware.

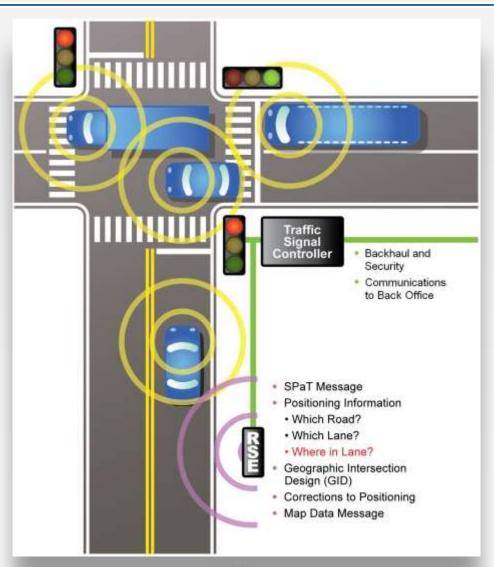
Devices compliant with the 5.9 GHz DSRC RSU Specification v4.0 are expected to be available fall 2014.

Other connected vehicle deployments are encouraged to use equipment compliant with the RSU specification v4.0.

Results from Safety Pilot and Integrated V2I Prototype development will be used to develop a V2I reference implementation.

V2I Reference Implementation

- A system of specifications and requirements that allow the various components of V2I hardware, software, and firmware to work together
- An agency will be able to select the capabilities and applications desired at a given installation
- Under development now
 - Initial testing Summer 2014
 - Field testing in Orlando late 2014



Enabling Technologies: Connected Vehicle Data

Data

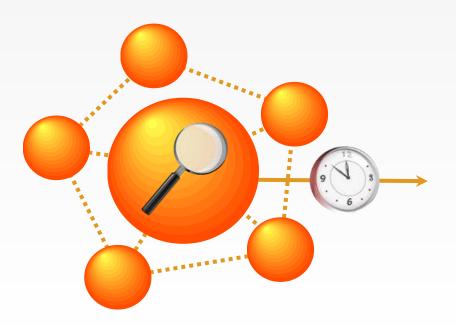
V2I Communications Support Safety, Mobility, and Environmental Applications:

- Signal Phase and Timing (SPaT) data supports red light violation warning (safety), arterial speed harmonization (mobility), and eco-signal operations (environment).
- The Basic Safety Message, developed for V2V safety applications, also supports the intelligent traffic signal systems mobility application.
- Probe data supports transportation operations, traveler information, transportation planning, and asset management.

Common functions shared across applications: positioning, mapping, and communications.

Research Data Exchange

www.its-rde.net



- Promotes sharing of archived and real-time connected vehicle data collected in USDOT-sponsored research efforts and field tests
- 2 TB of well-organized and documented data
- Drawn from a dozen geographic locations across the country
- Multi-source data (traditional sensor plus probe and connected vehicle data)
- Search and download functions
- Available now

Standards in Connected Vehicles

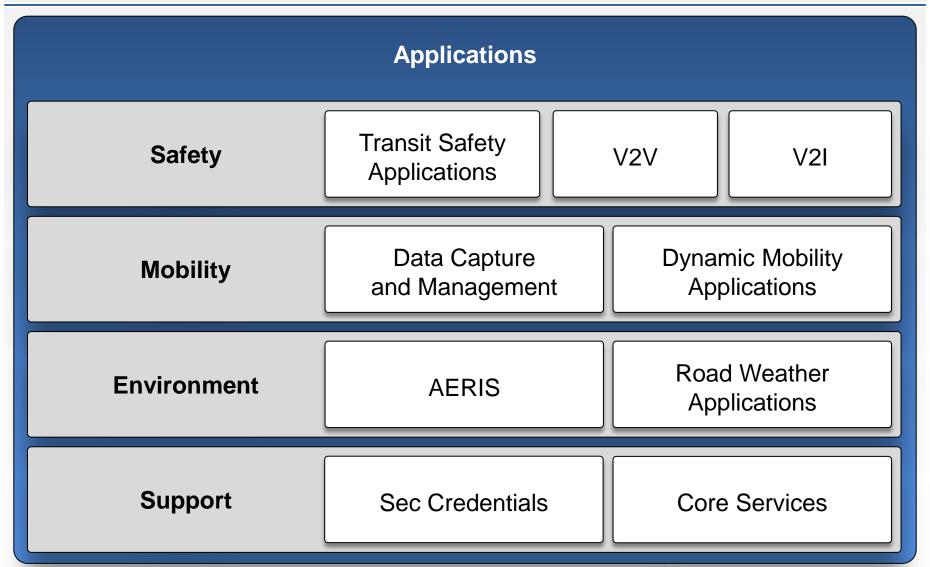
Standards

Interface Standards Are Essential

USDOT is working with public and private sectors to define:

- Communications standards for DSRC
- Other media, e.g., 4G LTE and/or HD radio may be used for appropriate applications
- Information exchange standards:
 - Message sets for V2X [SAE J2735]
 - Minimum performance requirements for V2X messaging [SAE J2945.x]
 - Signal controller messages
 - Certification processes will also be established to ensure off-theshelf interoperability of devices

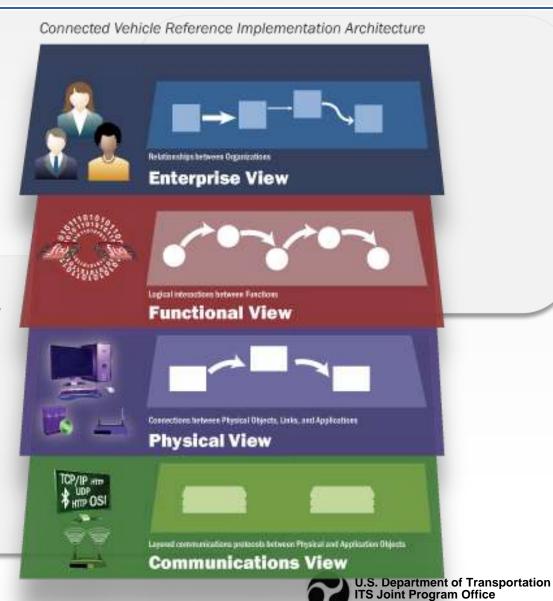
Connected Vehicle Reference Implementation Architecture (CVRIA)



CVRIA: A *Framework* for integrating technologies and identifying interfaces for standardization

- Enterprise
- Functional
- Physical
- Communications

Under development now



Affiliated Connected Vehicle Test Beds

- The vision is to have multiple interoperable locations as part of one connected system moving toward nation-wide deployment.
 - Common architecture
 - Common standards
 - Independent operations
 - Shared resources



USDOT Test Bed Resources

- Qualified Product List for RSE
 - Five vendors
- Qualified Product List for Onboard Equipment (OBE)
 - Vehicle Awareness Devices
 - Aftermarket Safety Devices
- Portable RSE Trailers
- Network Listeners/Sniffers

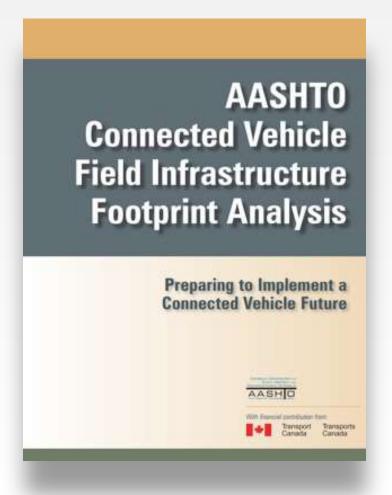
- Test Bed Operations Staff
- Signal Phase and Timing (SPaT) Resources
 - Listeners
 - Interface standards from FHWA
- Security Credential Management System (SCMS)
 - 1609.2 certificate management system





Policy Issues: Deployment Scenarios

- USDOT asked AASHTO to create a vision of a national connected vehicle infrastructure
- Provides guidance to state agencies and DOTs, including:
 - Infrastructure needs at regional and national levels
 - Illustrations of typical deployments at signalized intersections, urban freeways, rural roadways, international border crossings, and other locations
 - System and equipment needs and siting requirements
 - Operations, maintenance and institutional issues
 - Deployment cost estimates
- Available now



Policy Issues: Security

- Challenges
 - Message validity
 - Security entity
 - Network
 - Business models for security operations
 - Certification Processes for Equipment and Systems
- Security Credential Management System (SCMS)
 - Under development now, will be available in prototype form for pilot deployments



Policy Issues: Privacy

- A user cannot be tracked along his journey or identified without appropriate authorization.
- User privacy can be protected further through policy means. We've done initial privacy analysis of the system and will have privacy experts do a comprehensive review of any final system proposed for implementation





Key Connected Vehicle Research Findings

- Connected Vehicle research is going on not only in USDOT-sponsored efforts but also in the private sector and among agencies
- Initial assessments of potential impacts for connected vehicle technologies are compelling
 - Safety, mobility and environmental
- Interest is high in moving forward with connected vehicle
- Not all current connected vehicle technologies are mature
- Not all institutional and policy issues are resolved
- HOWEVER, our assessment is that the current state is one of significant opportunity for the pilot deployment of connected vehicle concepts
 - Plant the seeds that leads to full integration of successful CV concepts into operational practice

The Connected Vehicle Pilot Deployment Program

Kate Hartman
USDOT Intelligent Transportation Systems
Program Manager, CV Pilot Deployment Program

Background

- Multiple existing ITS and Connected Vehicle programs planning field tests
- Infeasible for all programs to conduct independent large-scale tests and deployments
- Cross-cutting needs have been broadly identified for many applications
- Clear opportunities for synergy among technologies, messages, and concepts
- Our assessment is that the current state of connected vehicle technology:
 - Clear opportunity to successfully deploy collections of complementary connected vehicle applications
 - Pilot deployments can have a cost-beneficial impact in the short-term
 - Potentially transformative impacts in the long-term

CV Pilot Program Vision

- The <u>VISION</u> of the Connected Vehicle Pilots program is
 - to conduct research,
 - promote technology transfer,
 - and facilitate the nationwide deployment of a Connected Vehicle environment

CV Pilot Program Goals

- The GOALS of the CV Pilots Program are to
 - accelerate early deployment of Connected Vehicle technology
 - understand and estimate benefits associated with deployment
 - identify and solve key issues related to technical and institutional barriers

The Connected Vehicle Environment

- A Connected Vehicle Environment is
 - a robust (resilient, secure, and operational) transportation environment
 - where vehicles, mobile devices, and fixed infrastructure communicate
 - agnostic to communications media selected based on function and cost
 - improving traveler safety and traveler & goods mobility while minimizing environmental impacts

Organizing Principles

- Pilots will be *pilot deployments*, that is, real-world environment deployments
 - If successful, deployed technologies are expected to remain as permanent operational elements
- There will be <u>multiple</u> pilot sites over time
 - Each site will have different needs, focus and applications
 - That is, pilot deployments must address a critical problem
 - The needs of each site must drive the application selection process
- Pilot deployments are expected to be both <u>large-scale and multi-modal</u>
 - <u>Large-scale</u> implies pilot deployments will have measureable impact, not a specific minimum geographic or vehicle fleet size
 - Sites will deploy <u>multiple applications</u> drawing on the products of USDOT and other connected vehicle research

Proposed Pilot Deployment Requirements

- Multiple connected vehicle applications must be deployed together
 - Cost-effectively leveraging captured CV and mobile device data
 - Address multi-modal problems
- Pilot deployments should leverage USDOT-sponsored research
 - Need not include all applications (in fact, this is unlikely to be practical)
 - May include new connected vehicle applications not considered by USDOT
 - All applications selected must work and have an impact
- Pilot deployments should include the capture of data from multiple sources
 - At a minimum, vehicles must represent one source of data used in the pilot deployment
- Multiple forms of communications technologies are desired
 - DSRC desired as one communication technology

Proposed Pilot Deployment Requirements (continued)

- Well-defined, focused, quantitative performance measures
 - Support an independent evaluation effort
- Share pilot deployment data and lessons learned
 - While protecting privacy and intellectual property
- Security and credentialing management system
- Integrated or carry-in devices for connected vehicles capable of generating an SAE J2735 Basic Safety Message (BSM)

Key Milestones for the CV Pilots Program

Request for Information (RFI) IssuedMarch 2014

CV Pilot Program Stakeholder Workshop
 April 2014

Regional Pre-Deployment Workshop/Webinar
 Series (TBD)
 Summer-Fall 2014

Solicitation for Wave 1 Pilot Deployment Concepts
 Early 2015

Wave 1 Pilot Deployments Award(s)September 2015

Solicitation for Wave 2 Pilot Deployment Concepts
 Early 2016

Wave 2 Pilot Deployments Award(s)September 2016

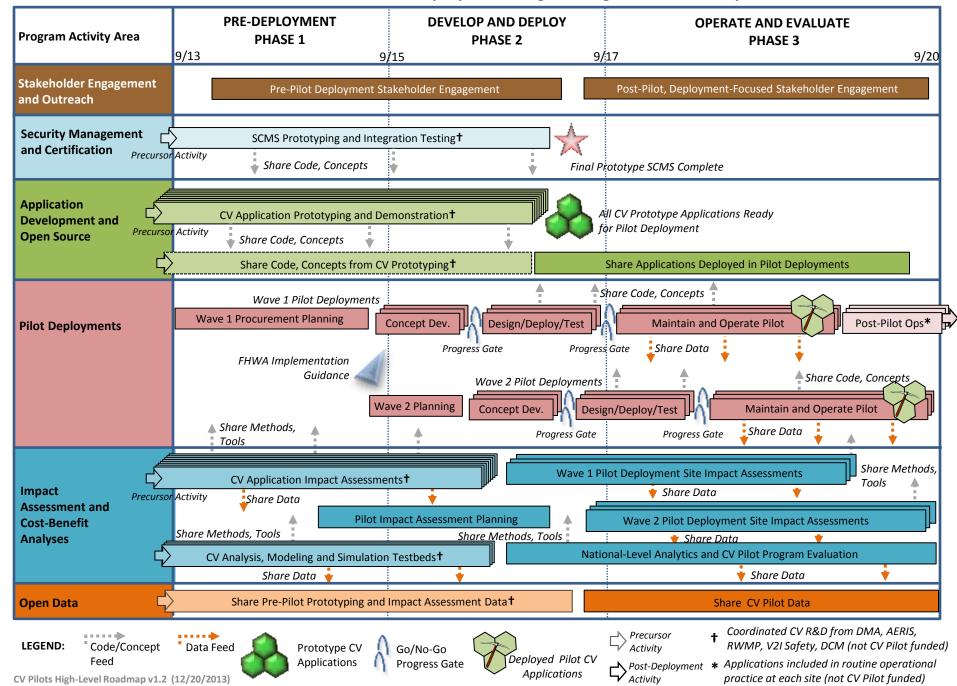
■ Pilot Deployments Complete September 2020

DRAFT

CV Pilots High-Level Roadmap v1.2 (12/20/2013)

Connected Vehicle Pilot Deployment Program: High-Level Roadmap

DRAFT



Applications

Getting Ready for Pilot Deployments

- Get familiar with USDOT connected vehicle research products
- Attend upcoming stakeholder events
 - We will cover these in our last session of the day
- Find like-minded partners from the public and private sectors to create a pilot deployment concept
 - Grounded in local needs, i.e., solving real transportation problems
 - Targeting specific and meaningful performance goals
 - Built around a cost-effective collection of connected vehicle applications that leverages common data capture and dissemination

Stakeholder Q&A

Creating Connected Vehicle Pilot Deployment Concepts

Moderator:

Jeff Spencer (FTA)

Purpose of this Session

- Describe the Pilot Deployment Concept Development Process
 - Identify Local Needs
 - Set Performance Goals
 - Select CV Applications That Work Together Meet Those Goals
- Provide Example Pilot Concepts from Hypothetical Locations
 - Hypothetical, but realistic examples of localities applying the pilot deployment concept development process
- Examples Are Technology and Communications Media Neutral
- These Examples Are NOT Templates
 - USDOT does not seek pilot deployments identical to these examples
 - USDOT seeks pilot deployments tailored to local needs and goals

Pilot Deployment Concept Development Process



Needs

- Driven by the needs of multiple stakeholders
- Related to one or more safety, mobility, or environmental issues

Goals

- Directly relate to needs
- Quantitative, measureable, meaningful
- Concise list of a "few good measures" with stakeholder buy-in

CV Apps

- Selected to work together to cost-effectively meet pilot deployment goals
- Integrated into operational practice as permanent deployed features

Deployment Concepts in this Session are Hypothetical Results of a Local Process

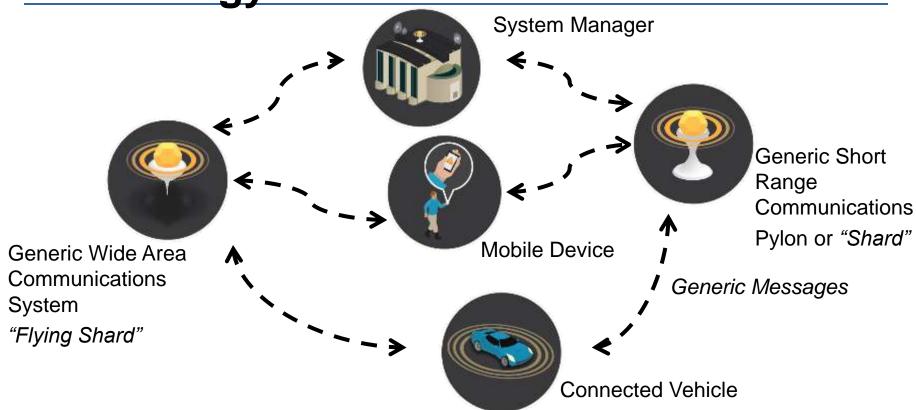
- The Pilot Deployment Concept Development Process is paramount, not the concepts
- Example Pilot Deployment Concepts in this Session are:
 - Used only to illustrate the pilot development
 - Hypothetical and do not reflect preferred deployment concepts
 - Realistic enough to surface related goals and needs, and potential synergies from multiple connected vehicle applications
- These Examples Are NOT Templates
 - USDOT does not seek pilot deployments identical to these examples
 - USDOT seeks pilot deployments tailored to local needs and goals

Q: What do
Downtown Sunnyside,
the Halleck Expressway,
the I-876 Corridor,
District 13 and
Greypool County
all have in common?

- A: They are only examples, not templates
- B: They are used to illustrate the pilot deployment concept development process
- C: They are not real.
- D: All of the above.



Deployment Concepts in this Session are Technology Neutral



- Graphics are used to illustrate the concept, not a system design
 - Examples illustrated here are not preferred, only to show how messages are expected to pass among mobile devices, connected vehicles, and communications media

Example Pilot Deployment Concepts: The Remainder of the Session

Downtown Sunnyside Ben McKeever

H.W. Halleck ExpresswayBob Rupert

Greypool CountyCarl Andersen

District 13 Connected Operations
 Gabe Guevara

■ I-876 Productivity Corridor Randy Butler

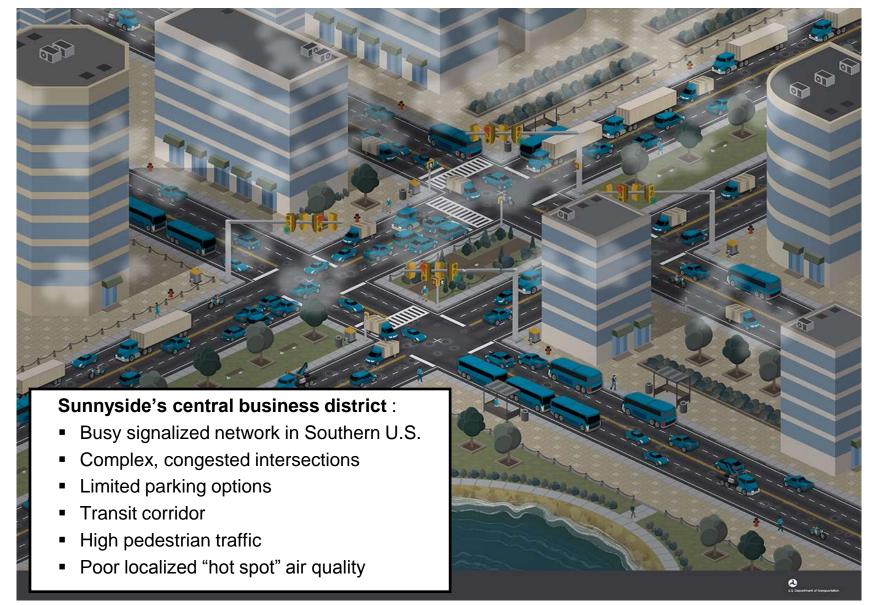
Stakeholder Q&A (25 minutes)Jeff Spencer

- Each presenter will have about 15-20 minutes to talk about the each of these examples
 - We will take one or two clarifying questions specific to the example
- Please hold general questions for the end, where we have a block of time to answer questions

Example CV Pilot Deployment Concepts: Downtown Sunnyside

Ben McKeever (FHWA)

Downtown Sunnyside



Stakeholders Convene and Identify Key Transportation Challenges

Mobility

- Heavy congestion at peak times
- Transit vehicles schedule reliability

Safety

- Pedestrian-vehicle conflicts
- Crashes in unprotected left hand turns

Environment

- Emissions/Air Quality hot spots
- Poor progression results in wasted fuel

Stakeholder Set Three Key Improvement Targets

Metrics	Targets
Increase transit reliability	Transit vehicles on schedule 90% of the time
Improve pedestrian safety	Reduce pedestrian-vehicle conflicts by 50%
Improve hot spot air quality	Reduce emissions by 20%

Applications Considered for Improving Transit Reliability



V2I Safety

Red Light Violation Warning
Curve Speed Warning
Stop Sign Gap Assist
Spot Weather Impact Warning
Reduced Speed/Work Zone Warning
Pedestrian in Signalized Crosswalk
Warning (Transit)

V2V Safety

Emergency Electronic Brake Lights (EEBL)
Forward Collision Warning (FCW)
Intersection Movement Assist (IMA)
Left Turn Assist (LTA)
Blind Spot/Lane Change Warning
(BSW/LCW)
Do Not Pass Warning (DNPW)
Vehicle Turning Right in Front of Bus
Warning (Transit)

Road Weather

Motorist Advisories and Warnings (MAW)
Enhanced MDSS
Vehicle Data Translator (VDT)
Weather Response Traffic Information

(WxTINFO)

Environment

Eco-Approach and Departure at
Signalized Intersections
Eco-Traffic Signal Timing
Eco-Traffic Signal Priority
Connected Eco-Driving
Wireless Inductive/Resonance Charging
Eco-Lanes Management

Centrol

Transit Reliability

Low Emissions Zone Management AFV Charging / Fueling Information

Eco-Smart Parking

Ico-Ramp Metering

Dynamic Eco-Routing (light vehicle, transit, freight)

Eco-ICM Decision Support System

Agency Data

Probe-based Pavement Maintenance
Probe-enabled Traffic Monitoring
Vehicle Classification-based Traffic
Studies
CV-enabled Turning Movement &
Intersection Analysis
CV-enabled Origin-Destination Studies
Work Zone Traveler Information

Mobility

Advanced Traveler Information System Intelligent Traffic Signal System (I-SIG)

Signal Priority (transit, freight)

Mobile Accasible Pedestrian Signal System (PED-StG)

Emergency Vehicle Preemption (PREEMPT)
Dynamic Speed Harmonization (SPD-HARM)
Queue Warning (Q-WARN)

Cooperative Adaptive Cruise Control (CACC) Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG) Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)

Emergency Communications and Evacuation (EVA)

Connection Protection (T-CONNECT)

Dynamic Transit Operations (T-DISP)

Dynamic Ridesharing (D-RIDE)

Freight-Specific Dynamic Travel Planning and Performance

Drayage Optimization

Smart Roadside

Wireless Inspection Smart Truck Parking



Applications Considered for Improving Pedestrian Safety



V2I Safety

Red Light Violation Warning
Curve Speed Warning
Stop Sign Gap Assist
Spot Weather Impact Warning
Reduced Speed/Work Zone Warning

Pedestrian in Signalized Crosswalk Warning (Transit)

V2V Safety

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Vehicle Data Translator (VDT)

Weather Response Traffic Information (WxTINFO)

Environment

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Eco-Traffic Signal Timing

Con Pedestrian Vehicle

Eco Lanes Management
Eco Speed Harmonization

Eco-Cooperative Adaptive Cruise Control

Eco Traveler Information

Eco-Ramp Metering

Low Emissions Zone Management

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U.S. Department of Transportation ITS Joint Program Office

Applications Considered for Improving the Environment



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Curve Speed Warning
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Warning (Transit)

V2V Safety

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Environment

Eco-Approach and Departure at Signalized Intersections
Eco-Traffic Signal Timing ___

Eco-Traffic Signal Priority

Connected Eco-Driving

Wireless Inductive/Resonance Charging

Eco-Lanes Management

Eco-Speed Harmonization

Eco-Cooperative Adaptive Cruise Control

Eco-Traveler Information

Eco-Ramp Metering

Low Emissions Zone Management

AFV Charging / Fueling Information

Eco-Smart Parking

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Freight-Specific Dynamic Travel Planning and Performance

Drayage Optimization

Smart Roadside

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Connected Vehicle Applications Selected in Performance-Driven Approach

Improve Transit Reliability

- Connection Protection (T-CONNECT)
- Transit Signal Priority

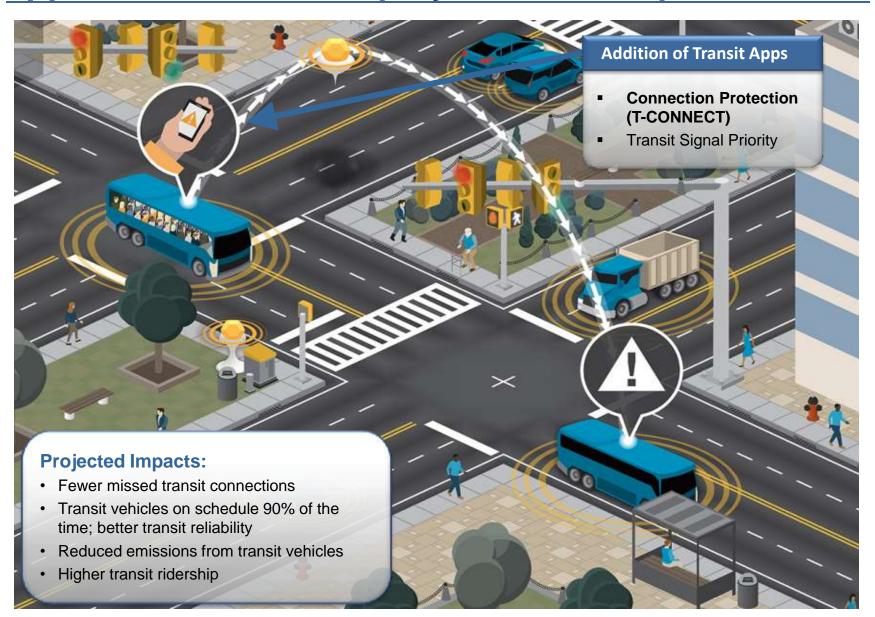
Improve Pedestrian Safety

- Mobile Accessible Pedestrian Signal System (PED-SIG)
- Pedestrian in Signalized Crosswalk Warning
- Intersection Movement Assist (IMA)

Improve Hot Spot Air Quality

- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing

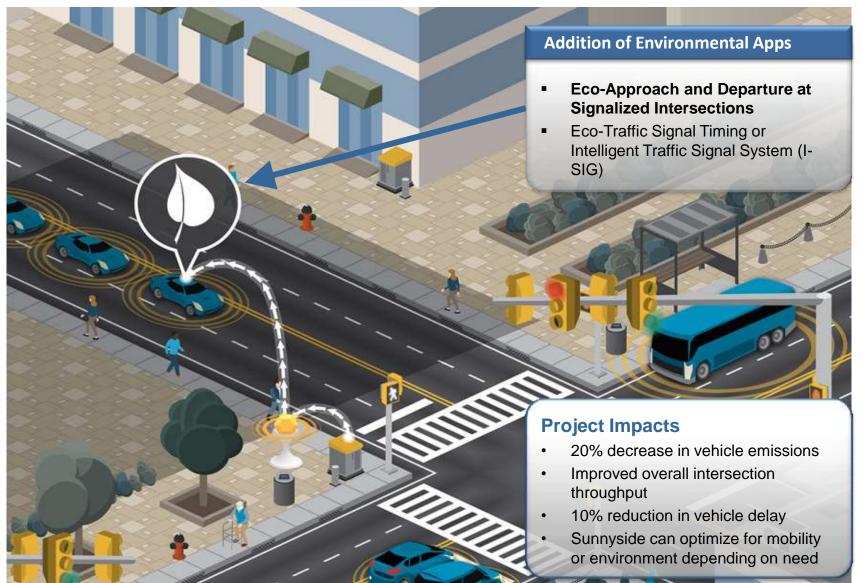
Projected Synergies and Impacts from Transit Applications in the Deployment Concept



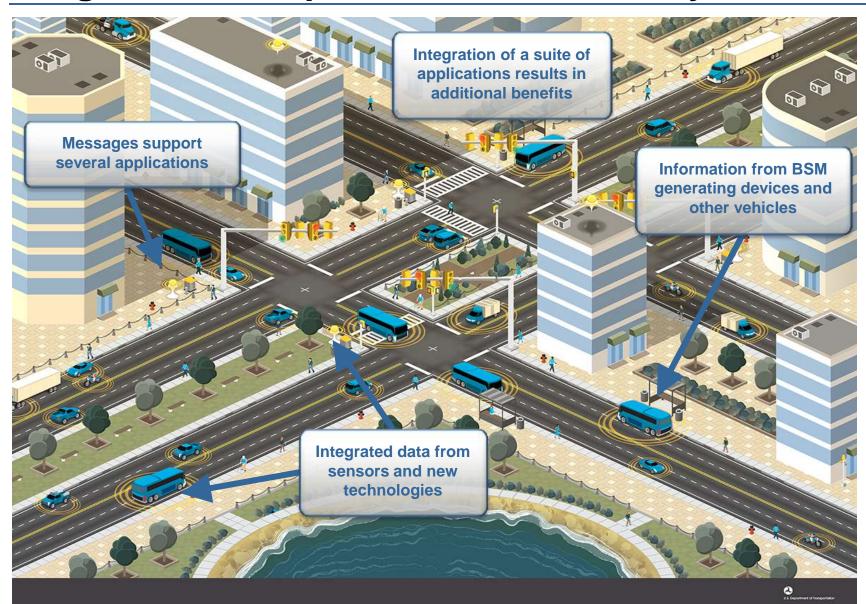
Projected Synergies and Impacts from Pedestrian Safety Apps in the Deployment Concept



Projected Synergies and Impacts from Environmental Apps in the Deployment Concept



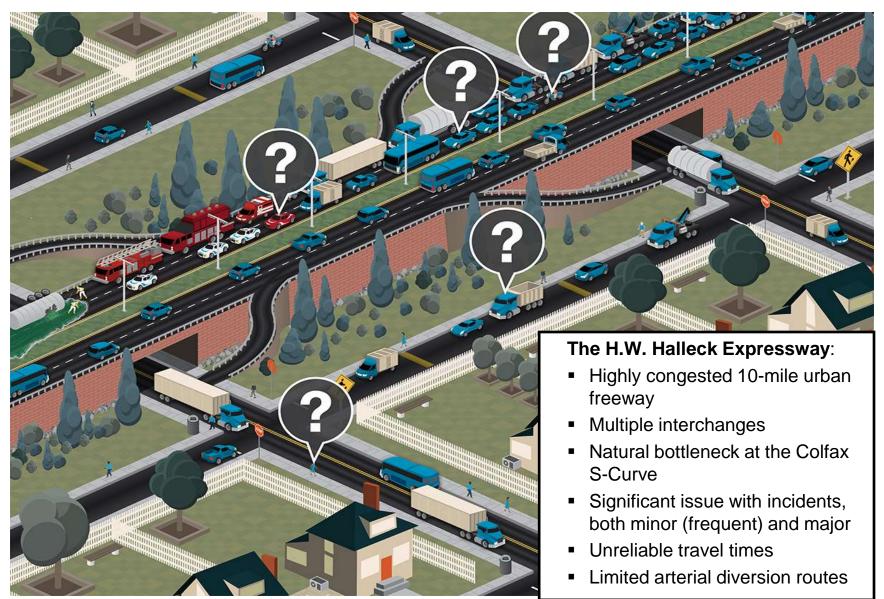
Integrated Concept for Downtown Sunnyside



Example CV Pilot Deployment Concepts: H.W. Halleck Expressway

Bob Rupert (FHWA)

H.W. Halleck Expressway



Stakeholders Convene and Identify Key Transportation Challenges

Recurrent Congestion

- Colfax S-curve is a natural bottleneck
- Multiple interchanges leads to merge/weave delays

Incidents

- Response to major incidents lack coordination among agencies
- Frequent minor incidents makes travel times unpredictable

Diversion Management

- Arterial diversion routes have limited capacity, easily overwhelmed
- Mass diversions lead to gridlock on local arterials

Stakeholder Set Three Key Improvement Targets

Metrics	Targets
Improve Colfax S-Curve throughput	Increase peak period throughput by 8%
Reduce major incident delays	Cut delay from major incidents by 25%
Manage diversions better	"Zero tolerance" for arterial gridlock during freeway incidents

Applications Considered to Improve Bottleneck Throughput

V2I Safety

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Vehicle Turning Right in Front of Bus
Warning (Transit)

Road Weather

Motorist Advisories and Warnings (MAW) Enhanced MDSS

Vehicle Data Translator (VDT)

Weather Response Traffic Information (WxTINFO)

Environment

Eco-Approach and Departure at Signalized Intersections
Eco-Traffic Signal Timing

Eco-Traffic Signal Priority

Connected Eco-Driving

Wireless Inductive/Resonance Charging

Eco-Lanes Management

Eco-Speed Harmonization

Eco-Cooperative Adaptive Cruise Contro

Eco-Traveler Information

Eco-Ramp Metering

Low Emissions Zone Management

AFV Charging / Fueling Information

tra Improve Colfax S-Curve

Eq Throughput

Probe-based Pavement Maintenance
Probe-enabled Traffic Monitoring

Vehicle Classification-based Traffic

Studies

Ec

CV-enabled Turning Movement &

Intersection Analysis

CV-enabled Origin-Destination Studies
Work Zone Traveler Information

Mobility

Advanced Traveler Information System Intelligent Traffic Signal System (I-SIG)

Signal Priority (transit, freight)

Mobile Accessible Pedestrian Signal System (PED-SIG)

Emergency Vehicle Preemption (PREEMPT)

Dynamic Speed Harmonization (SPD-HARM)

Queue Warning (Q-WARN)

Cooperative Adaptive Cruise Control (CACC)
Incident Scene Pre-Arrival Staging Guidance
for Emergency Responders (RESP-STG)
Incident Scene Work Zone Alerts for Drivers

and Workers (INC-ZONE)

Emergency Communications and Evacuation (EVAC)

Connection Protection (T-CONNECT)

Dynamic Transit Operations (T-DISP)

Dynamic Ridesharing (D-RIDE)

Freight-Specific Dynamic Travel Planning and Performance

Smart Roadside

Wireless Inspection Smart Truck Parking



U.S. Department of Transportation ITS Joint Program Office

Applications Considered to Reduce Incident Delay

V2I Safety

Red Light Violation Warning **Curve Speed Warning** Stop Sign Gap Assist Spot Weather Impact Warning Reduced Speed/Work Zone Warning Pedestrian in Signalized Crosswalk Warning (Transit)

V2V Safety

Emergency Electronic Brake Lights (EEBL) Forward Collision Warning (FCW) Intersection Movement Assist (IMA) Left Turn Assist (LTA) Blind Spot/Lane Change Warning (BSW/LCW) Do Not Pass Warning (DNPW) Vehicle Turning Right in Front of Bus

Road Weather

Warning (Transit)

(WxTINFO)

Motorist Advisories and Warnings (MAW) Enhanced MDSS Vehicle Data Translator (VDT) Weather Response Traffic Information

Environment

Eco-Approach and Departure at Signalized Intersections **Eco-Traffic Signal Timing Eco-Traffic Signal Priority** Connected Eco-Driving Wireless Inductive/Resonance Charging

Reduce Incident Delay

AFV Charging / Fueling Information **Eco-Smart Parking** Dynamic Eco-Routing (light vehicle, transit, freight) **Eco-ICM Decision Support System**

Agency Data

Probe-based Pavement Maintenance Probe-enabled Traffic Monitoring Vehicle Classification-based Traffic **Studies** CV-enabled Turning Movement & Intersection Analysis CV-enabled Origin-Destination Studies Work Zone Traveler Information

Mobility

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Signal Priority (transit, freight)

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Queue Warning (Q-WARN)

bntrol

Cooperative Adaptive Cruise Control (CACC)

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Incident Scene Work Zone Alerts for **Drivers and Workers (INC-ZONE)**

Emergency Communications and Evacuation (EVAC)

Connection Protection (T-CONNECT)

Dynamic Transit Operations (T-DISP)

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Freight-Specific Dynamic Travel Planning and Performance

Smart Roadside

Wireless Inspection **Smart Truck Parking**



U.S. Department of Transportation ITS Joint Program Office

Applications Considered to Manage Diversions Better

V2I Safety

Red Light Violation Warning **Curve Speed Warning** Stop Sign Gap Assist Spot Weather Impact Warning Reduced Speed/Work Zone Warning Pedestrian in Signalized Crosswalk Warning (Transit)

V2V Safety

Emergency Electronic Brake Lights (EEBL) Forward Collision Warning (FCW) Intersection Movement Assist (IMA) Left Turn Assist (LTA) Blind Spot/Lane Change Warning (BSW/LCW)

Do Not Pass Warning (DNPW) Vehicle Turning Right in Front of Bus Warning (Transit)

Road Weather

Motorist Advisories and Warnings (MAW) Enhanced MDSS Vehicle Data Translator (VDT)

Weather Response Traffic Information (WxTINFO)

Environment

Eco-Approach and Departure at Signalized Intersections **Eco-Traffic Signal Timing Eco-Traffic Signal Priority** Connected Eco-Driving Wireless Inductive/Resonance Charging

Ec **Zero Tolerance for** Ec **Arterial Gridlock Under** Ec **Incident Conditions** Ec

Ec

Low

AFV Charging / Fueling Information **Eco-Smart Parking** Dynamic Eco-Routing (light vehicle, transit, freight)

Eco-ICM Decision Support System

Agency Data

Probe-based Pavement Maintenance Probe-enabled Traffic Monitoring Vehicle Classification-based Traffic **Studies** CV-enabled Turning Movement & Intersection Analysis CV-enabled Origin-Destination Studies Work Zone Traveler Information

Mobility

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trol

Cooperative Adaptive Cruise Control (CACC) Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG) Incident Scene Work Zone Alerts for Drivers

and Workers (INC-ZONE) **Emergency Communications and Evacuation** (EVAC)

Connection Protection (T-CONNECT)

Dynamic Transit Operations (T-DISP)

Dynamic Ridesharing (D-RIDE)

Freight-Specific Dynamic Travel Planning and Performance

Drayage Optimization

Smart Roadside

Wireless Inspection **Smart Truck Parking**



U.S. Department of Transportation ITS Joint Program Office

Connected Vehicle Applications Selected in Performance-Driven Approach

Improve Bottleneck Throughput

- Speed Harmonization and Queue Warning
- Emergency Electronic Brake Lights and Forward Collision Warning

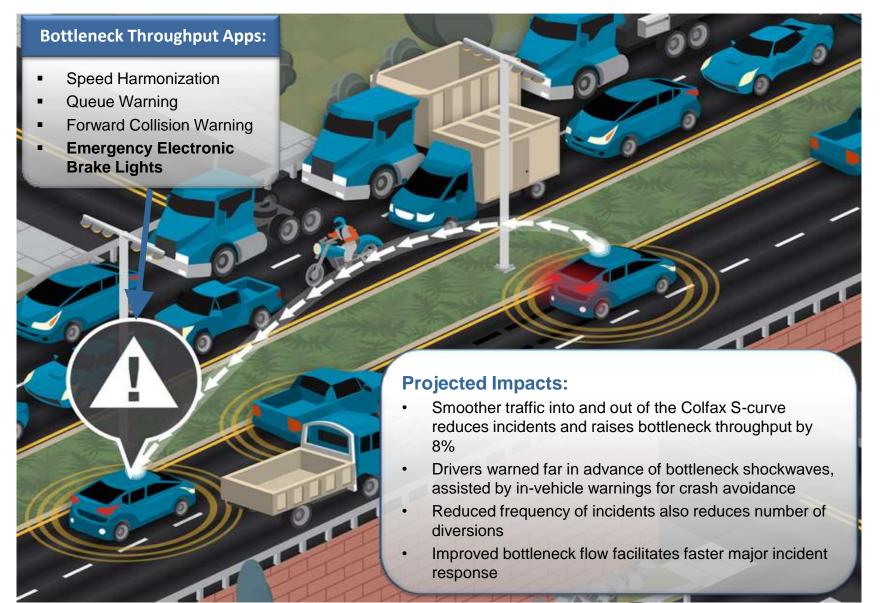
Reduce Incident Delay

- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
- Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)

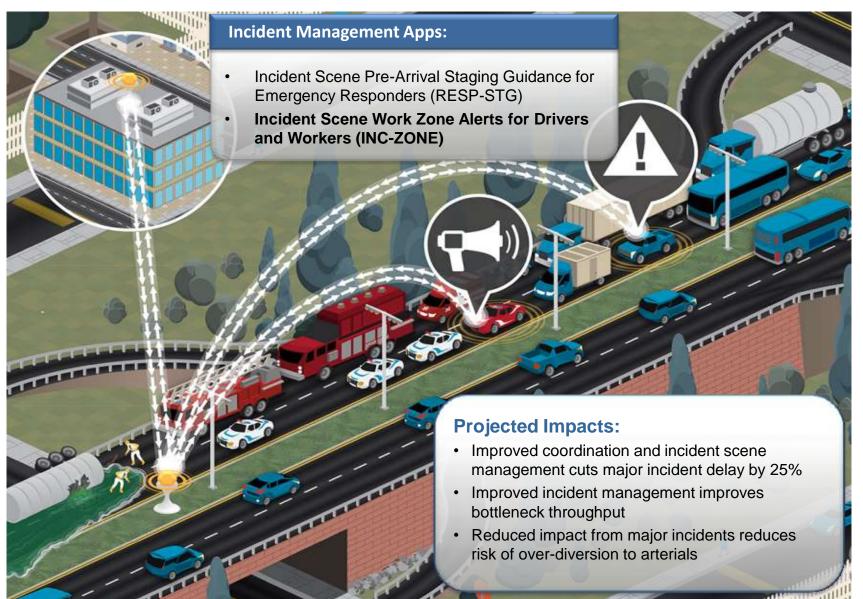
Manage Diversions Better

- EnableATIS
- Intelligent Signal Control (I-SIG)

Projected Synergies and Impacts from Bottleneck Throughput Applications in the Deployment Concept



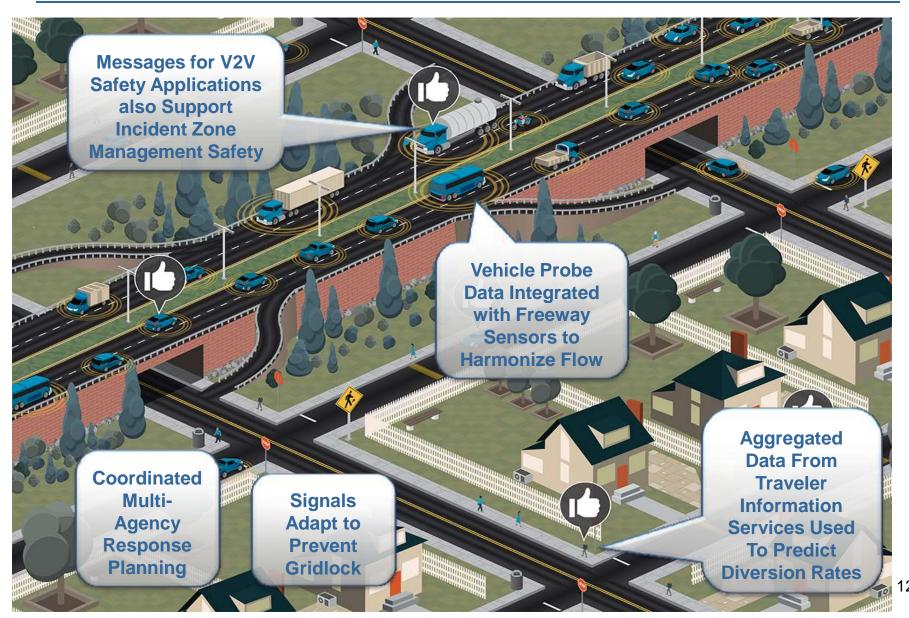
Projected Synergies and Impacts from Incident Management Applications in the Deployment Concept



Projected Synergies and Impacts from Diversion Management Applications in the Deployment Concept



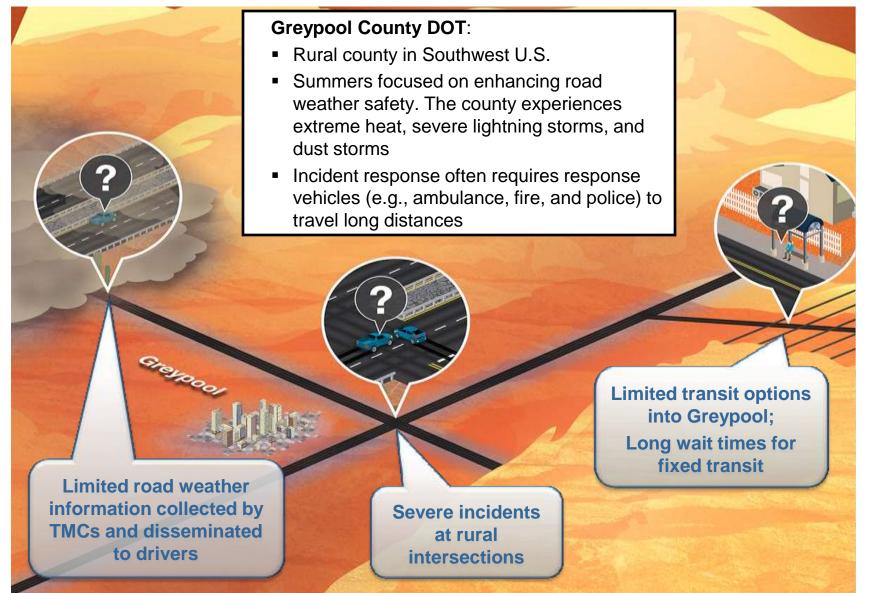
Integrated Concept for H. W. Halleck Expressway



Example CV Pilot Deployment Concepts: Greypool County

Carl Andersen (FHWA)

Greypool County Operations



Stakeholders Convene and Identify Key Transportation Challenges

Improve Safety at Rural Intersections

- Poor line of sight at intersections and high speeds on the mainline often result is drivers misjudging gaps when departing from stop signs
- Red light running violations are prevalent at signalized intersections
- Collision at intersections when a vehicle is turning left result in the most severe crashes – often resulting in injuries and fatalities

Improve Accessibility in Greypool County

- Existing fixed route transit options do not serve the majority of the destinations in the county
- Transit stops are not always accessible to travelers and travelers often experience long wait times at transit stops

Improve Road Weather Information Dissemination

- Unpredictable weather (e.g., lightning storms, dust storms) during summer months often cause delays and impact safety
- Limited deployed devices in the field to collect road weather information
- Limited mechanisms to disseminated proactive road weather information to drivers

Stakeholder Set Three Key Improvement Targets

Metrics	Targets
Reduces crashes, injuries, and fatalities	Reduce crashes by 10%; injuries by 20%; and fatalities by 30%
Improve accessibility	Provide transit options to areas not being served by fixed transit in Greypool County Reduce wait times for transit riders by 20%
Improve collection and dissemination of road weather information	Increase road weather data collection footprint of road weather by 50% Increase availability of weather-related traveler information

Applications Considered for Improving Safety

V2I Safety

Red Light Violation Warning

Curve Speed Warning

Stop Sign Gap Assist

Spot Weather Impact Warning Reduced Speed/Work Zone Warning Pedestrian in Signalized Crosswalk Warning (Transit)

V2V Safety

Emergency Electronic Brake Lights (EEBL)
Forward Collision Warning (FCW)
Intersection Movement Assist (IMA)

Left Turn Assist (LTA)

Blind Spot/Lane Change Warning (BSW/LCW)

Do Not Pass Warning (DNPW)
Vehicle Turning Right in Front of Bus
Warning (Transit)

Road Weather

Motorist Advisories and Warnings (MAW) Enhanced MDSS

Vehicle Data Translator (VDT)

Weather Response Traffic Information (WxTINFO)

Environment

Eco-Approach and Departure at Signalized Intersections

Eco Traffic Signal Timing

Eco-Traffic Signal Priority

Connected Eco-Driving

Wireless Inductive/Resonance Charging

Eco Lanes Management

Eco-Eco-Improve Safety

Zco-Ramp Metering

Eco-

Low Emissions Zone Management

AFV Charging / Fueling Information

Eco-Smart Parking

Dynamic Eco-Routing (light vehicle, transit, freight)

Eco-ICM Decision Support System

Agency Data

Probe-based Pavement Maintenance Probe-enabled Traffic Monitoring Vehicle Classification-based Traffic Studies CV-enabled Turning Movement & Intersection Analysis

CV-enabled Origin-Destination Studies

Work Zone Traveler Information

Mobility

Advanced Traveler Information System Intelligent Traffic Signal System (I-SIG)

Signal Priority (transit, freight)

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Queue Warning (Q-WARN)

trol

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Emergency Communications and Evacuation (EVAC)

Connection Protection (T-CONNECT)

Dynamic Transit Operations (T-DISP)

Dynamic Ridesharing (D-RIDE)

Freight-Specific Dynamic Travel Planning and Performance

Drayage Optimization

Smart Roadside

Wireless Inspection Smart Truck Parking



Applications Considered for Increasing Accessibility

V2I Safety

Red Light Violation Warning
Curve Speed Warning
Stop Sign Gap Assist
Spot Weather Impact Warning
Reduced Speed/Work Zone Warning
Pedestrian in Signalized Crosswalk
Warning (Transit)

V2V Safety

Emergency Electronic Brake Lights (EEBL)
Forward Collision Warning (FCW)
Intersection Movement Assist (IMA)
Left Turn Assist (LTA)
Blind Spot/Lane Change Warning
(BSW/LCW)
Do Not Pass Warning (DNPW)
Vehicle Turning Right in Front of Bus

Road Weather

Warning (Transit)

(WxTINFO)

Motorist Advisories and Warnings (MAW) Enhanced MDSS Vehicle Data Translator (VDT) Weather Response Traffic Information

Environment

Eco-Approach and Departure at Signalized Intersections **Eco-Traffic Signal Timing Eco-Traffic Signal Priority** Connected Eco-Driving Wireless Inductive/Resonance Charging **Eco-Lanes Management** Eco-Speed Harmonization Ecotrol Eco-**Increase Accessibility** Eco-Ramp Metering Low Emissions Zone Management AFV Charging / Fueling Information **Eco-Smart Parking** Dynamic Eco-Routing (light vehicle, transit, freight)

Agency Data

Eco-ICM Decision Support System

Probe-based Pavement Maintenance
Probe-enabled Traffic Monitoring
Vehicle Classification-based Traffic
Studies
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Intersection Analysis
CV-enabled Origin-Destination Studies
Work Zone Traveler Information

Mobility

Advanced Traveler Information System Intelligent Traffic Signal System (I-SIG)

Signal Priority (transit, freight)

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Connection Protection (T-CONNECT)

Dynamic Transit Operations (T-DISP)

Dynamic Ridesharing (D-RIDE)

Freight-Specific Dynamic Travel Planning and Performance

Drayage Optimization

Smart Roadside

Wireless Inspection Smart Truck Parking



Applications Considered for Informing Drivers During Bad Weather

V2I Safety

Red Light Violation Warning
Curve Speed Warning
Stop Sign Gap Assist
Spot Weather Impact Warning
Reduced Speed/Work Zone Warning
Pedestrian in Signalized Crosswalk
Warning (Transit)

V2V Safety

Emergency Electronic Brake Lights (EEBL)
Forward Collision Warning (FCW)
Intersection Movement Assist (IMA)
Left Turn Assist (LTA)
Blind Spot/Lana Change Warning

Blind Spot/Lane Change Warning (BSW/LCW)

Do Not Pass Warning (DNPW)
Vehicle Turning Right in Front of Bus
Warning (Transit)

Road Weather

Motorist Advisories and Warnings (MAW) Enhanced MDSS

Vehicle Data Translator (VDT)

Weather Response Traffic Information (WxTINFO)

Environment

Eco-Approach and Departure at Signalized Intersections
Eco-Traffic Signal Timing

Eco-Traffic Signal Priority

Connected Eco-Driving

Wireless Inductive/Resonance Charging

Eco-Lanes Management

Eco-Speed Harmonization

Eco-Cooperative Adaptive Cruise Control

Eco-Traveler Information

Eco-Ramp Metering

Low

Manage Weather

Dynamic Eco-Routing (light vehicle transit, freight)

Eco-ICM Decision Support System

Agency Data

Probe-based Pavement Maintenance
Probe enabled Traffic Monitoring
Vehicle Classification-based Traffic
Studies

CV-enabled Turning Movement & Intersection Analysis CV-enabled Origin-Destination Studies Work Zone Traveler Information

Mobility

Advanced Traveler Information System Intelligent Traffic Signal System (I-SIG)

Signal Priority (transit, freight)

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Cooperative Adaptive Cruise Control (CACC) Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)

Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)

Emergency Communications and Evacuation (EVAC)

Connection Protection (T-CONNECT)

Dynamic Transit Operations (T-DISP)

Dynamic Ridesharing (D-RIDE)

Freight-Specific Dynamic Travel Planning and Performance

Drayage Optimization

Smart Roadside

Wireless Inspection Smart Truck Parking



Connected Vehicle Applications Selected in Performance-Driven Approach

Improve Safety

- Red Light Violation Warning
- Stop Sign Gap Assist
- Left Turn Assist

Increase Accessibility

Dynamic Transit Operations (T-DISP)

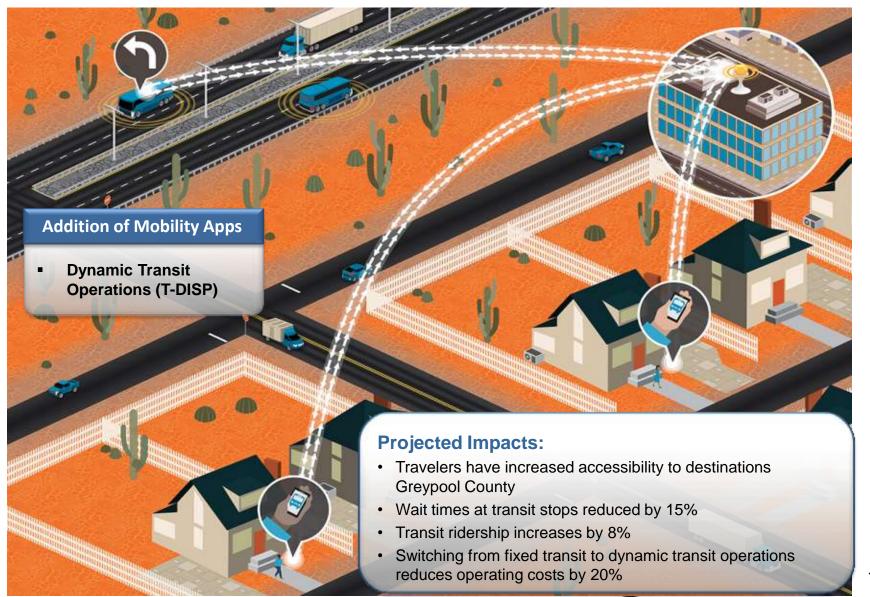
Informing Drivers During Bad Weather

Weather Response Traffic Information (WxTINFO)

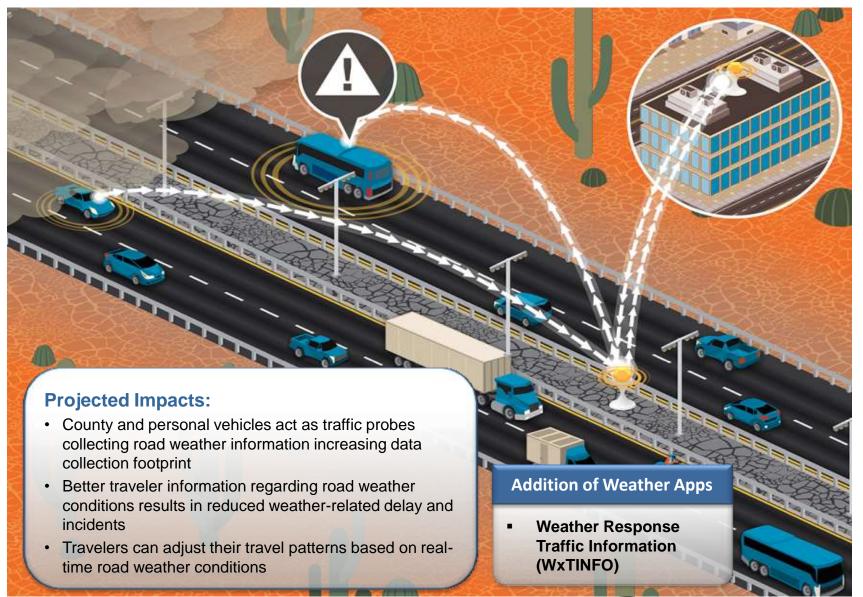
Projected Synergies and Impacts from Safety Applications in the Deployment Concept



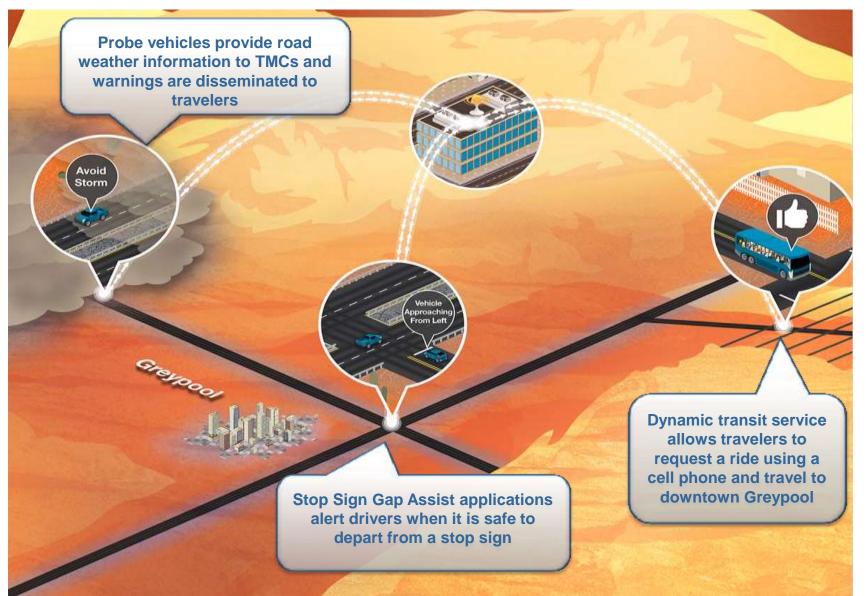
Projected Synergies and Impacts from Mobility Applications in the Deployment Concept



Projected Synergies and Impacts from Road Weather Applications in the Deployment Concept



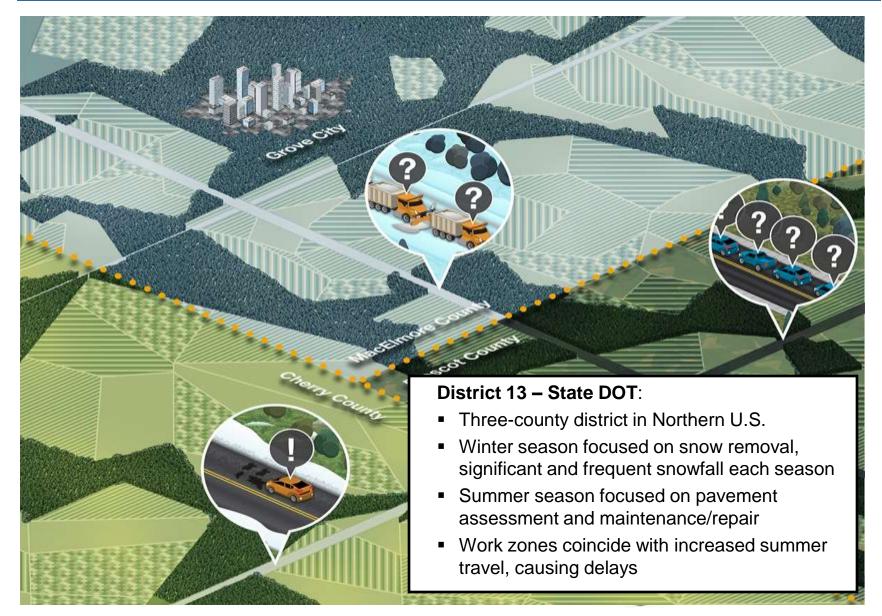
Integrated Concept for Greypool Operations



Example CV Pilot Deployment Concepts: District 13 Operations

Gabe Guevara (FHWA)

District 13 Operations



Stakeholders Convene and Identify Key Transportation Challenges

Improve Efficiency of Snow and Ice Operations

- Frequent snow falls during winter season increasingly costly while maintenance budgets continue to shrink
 - Optimize the use of materials and resources
 - Improve LOS Improve "Regain-time"
 - Improve safety and mobility (WRTM)
 - Conduct winter maintenance operations in a sustainable fashion
- Reduce fuel costs of plowing operations

Improve Pavement Maintenance

 Leverage technology to identify and classify pavement issues before they become critical without significant increases in operating costs

Improve Work Zone Planning and Management

- Unpredictable congestion during summer months due to concurrent roadwork and tourism
- Plan work zones better to reduce delays
- Improve traveler information on congestion resulting from work zones
- Improve work zone safety of workers and travelers

Stakeholder Set Three Key Improvement Targets

Metrics	Targets
Increase snow removal efficiency	Reduce snow removal time by 10% while lowering plowing operations costs 10% (fuel, materials, labor, etc.)
Improve ridability experience	Reduce number of customer calls regarding dangerous pot holes on roads by 25%
Reduce work zone delay	Cut work zone crashes and delay by 80% and 30% respectively during summer season

Applications Considered for Improving Snow Removal



V2I Safety

Red Light Violation Warning **Curve Speed Warning** Stop Sign Gap Assist Spot Weather Impact Warning Reduced Speed/Work Zone Warning Pedestrian in Signalized Crosswalk Warning (Transit)

V2V Safety

Emergency Electronic Brake Lights (EEBL) Forward Collision Warning (FCW) Intersection Movement Assist (IMA) Left Turn Assist (LTA) Blind Spot/Lane Change Warning (BSW/LCW) Do Not Pass Warning (DNPW) Vehicle Turning Right in Front of Pus

Road Weather

Motorist Advisories and Farnings (MAW)

Enhanced MDSS

Warning (Transit)

Vehicle Data Translator (VDT) Weather Response Traffic Information (WxTINFO)

Environment

Eco-Approach and Departure at Signalized Intersections **Eco-Traffic Signal Timing Eco-Traffic Signal Priority** Connected Eco-Driving Wireless Inductive/Resonance Charging **Eco-Lanes Management**

Eco-S trol Eco-Eco-**Snow Removal** Eco-Ramp Metering ow Emissions Zone Management

AFV Charging / Fueling Information **Eco-Smart Parking**

Dynamic Eco-Routing (light vehicle, transit, freight)

Eco-ICM Decision Support System

Agency Data

Probe-based Pavement Maintenance Probe-enabled Traffic Monitoring Vehicle Classification-based Traffic **Studies** CV-enabled Turning Movement & Intersection Analysis CV-enabled Origin-Destination Studies Work Zone Traveler Information

Mobility

Advanced Traveler Information System Intelligent Traffic Signal System (I-SIG)

Signal Priority (transit, freight)

Mobile Accessible Pedestrian Signal System (PED-SIG)

Emergency Vehicle Preemption (PREEMPT) Dynamic Speed Harmonization (SPD-HARM) Queue Warning (Q-WARN)

Cooperative Adaptive Cruise Control (CACC) Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG) Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)

Emergency Communications and Evacuation (EVAC)

Connection Protection (T-CONNECT) Dynamic Transit Operations (T-DISP)

Dynamic Ridesharing (D-RIDE)

Freight-Specific Dynamic Travel Planning and Performance

Drayage Optimization

Smart Roadside

Wireless Inspection **Smart Truck Parking**



U.S. Department of Transportation ITS Joint Program Office

Applications Considered for Improving Pavement Maintenance



V2I Safety

Red Light Violation Warning
Curve Speed Warning
Stop Sign Gap Assist
Spot Weather Impact Warning
Reduced Speed Work Zone Warning

Situational Awareness/
Enhanced Ride
Experience

Emergency Electronic Brake Lights (EEBL)
Forward Collision Warning (FCW)
Intersection Movement Assist (IMA)
Left Turn Assist (LTA)
Blind Spot/Lane Change Warning
(BSW/LCW)
Do Not Pass Warning (DNPW)

Road Weather

Vehicle Turning Right in Front of Bus

Warning (Transit)

Motorist Advisories and Warnings (MAW) Enhanced MDSS Vehicle Data Translator (VDT)

Weather Response Traffic Information (WxTINFO)

Environment

Eco-Approach and Departure at Signalized Intersections Eco-Traffic Signal Timing Eco-Traffic Signal Priority Connected Eco-Driving Wireless Inductive/Resonance Ch

Wireless Inductive/Resonance Charging

Eco-Lanes Management

Eco-Speed Harmonization

Eco-Cooperative Adaptive Cruise Control

Eco-Traveler Information

Eco-Ramp Metering

Low Emissions Zone Management

AFV Charging / Fueling Information

Eco-Smart Parking

Dynamic Eco-Routing (light vehicle, transit, freight)

Eco-ICM Decision Support System

Agency Data

Probe-based Pavement Maintenance

Probe-enabled Traffic Monitoring Vehicle Classification-based Traffic Studies

CV-enabled Turning Movement & Intersection Analysis

CV-enabled Origin-Destination Studies
Work Zone Traveler Information

Mobility

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Freight-Specific Dynamic Travel Planning and Performance

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U.S. Department of Transportation ITS Joint Program Office

Applications Considered for Improving Work Zones



V2I Safety

Red Light Violation Warning
Curve Speed Warning
Stop Sign Gap Assist
Spot Weather Impact Warning
Reduced Speed/Work Zone Warning
Pedestrian in Signalized Crosswalk
Warning (Transit)

V2V Safety

Emergency Electronic Brake Lights (EEBL)



Do Not Pass Warning (DNPW)
Vehicle Turning Right in Front of Bus
Warning (Transit)

Road Weather

Motorist Advisories and Warnings (MAW)
Enhanced MDSS
Vehicle Data Translator (VDT)
Weather Response Traffic Information

(WxTINFO)

Environment

Eco-Approach and Departure at Signalized Intersections **Eco-Traffic Signal Timing Eco-Traffic Signal Priority** Connected Eco-Driving Wireless Inductive/Resonance Charging **Eco-Lanes Management Eco-Speed Harmonization Eco-Cooperative Adaptive Cruise Control Eco-Traveler Information Eco-Ramp Metering** Low Emissions Zone Management AFV Charging / Fueling Information **Eco-Smart Parking** Dynamic Eco-Routing (light vehicle, transit, freight) **Eco-ICM Decision Support System**

Agency Data

Probe-based Pavement Maintenance
Probe-enabled Traffic Monitoring
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Studies
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CV-enabled Origin-Destination Studies

Work Zone Traveler Information

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Freight-Specific Dynamic Travel Planning and Performance

Drayage Optimization

Smart Roadside

Wireless Inspection Smart Truck Parking



U.S. Department of Transportation ITS Joint Program Office

Connected Vehicle Applications Selected in Performance-Driven Approach

Improve Snow Removal

Enhanced Maintenance Decision Support System

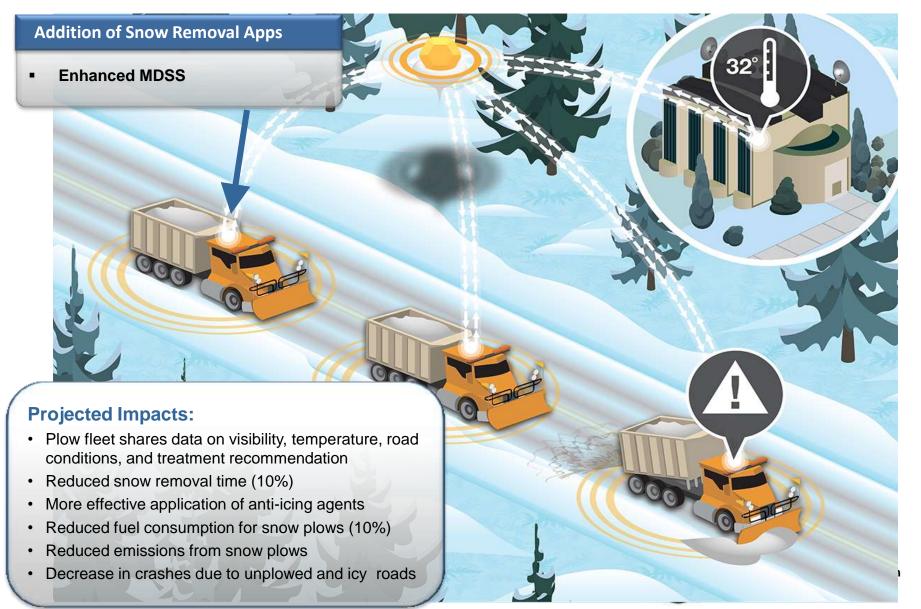
Improve Situational Awareness

Probe-based Pavement Maintenance

Improve Management of Work Zones

Work Zone Traveler Information

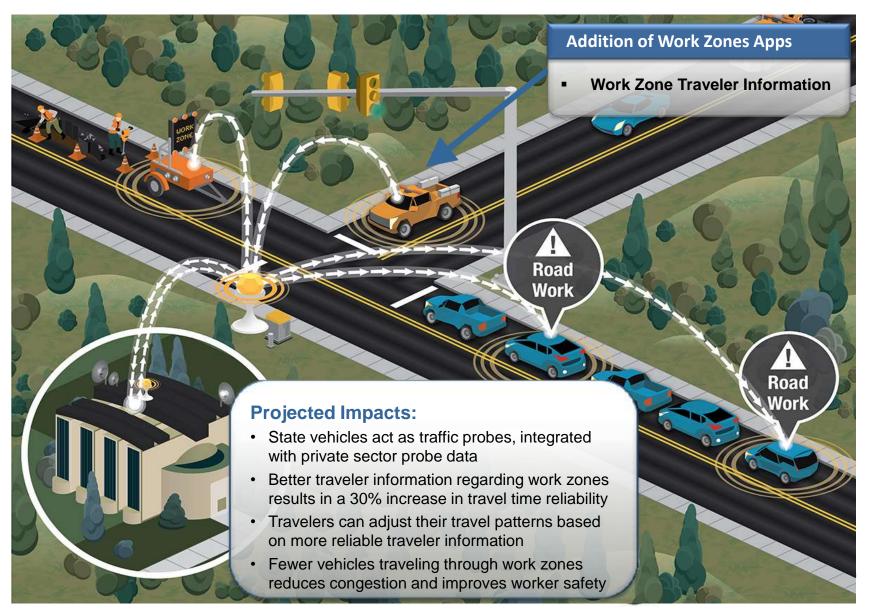
Projected Synergies and Impacts from Snow Removal Applications in the Deployment Concept



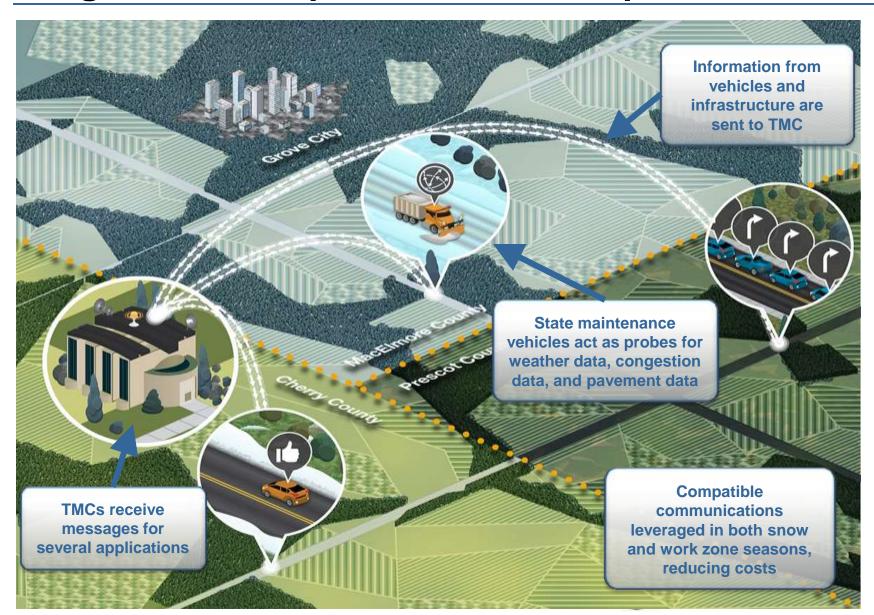
Projected Synergies and Impacts from Pavement Management Applications in the Deployment Concept



Projected Synergies and Impacts from Work Zone Applications in the Deployment Concept



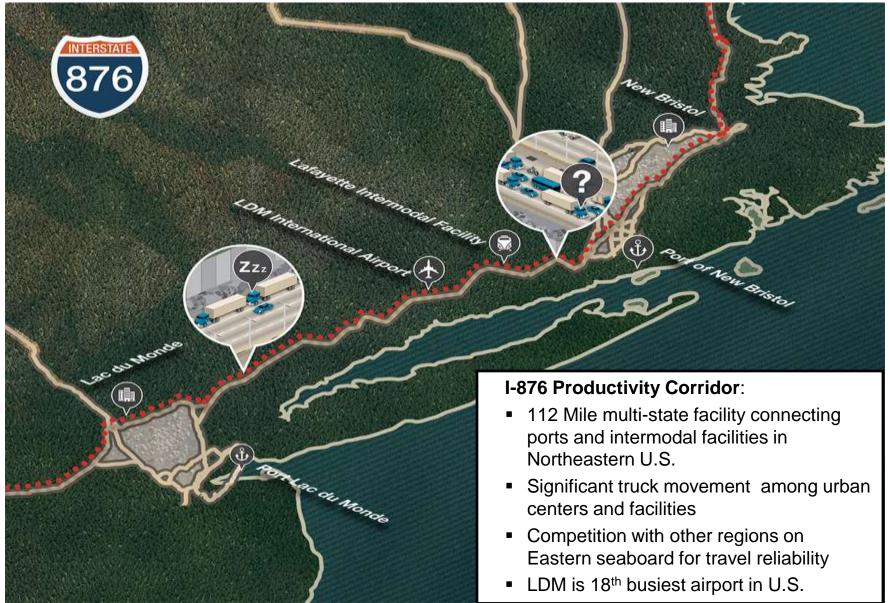
Integrated Concept for District 13 Operations



Example CV Pilot Deployment Concepts: I-876 Productivity Corridor

Randy Butler (FHWA)

I-876 Productivity Corridor



Stakeholders Convene and Identify Key Transportation Challenges

Freight Productivity

- Heavy congested freeways interferes with timely and reliable freight movement and hinders economic development
- Underutilized freight facilities, infrastructure, and mobile assets
- Frequent empty moves within the corridor create non-optimal utilization of assets
- Port, airport and inter-modal access subject to surge demand and long waits

Truck Safety

- Truck-vehicle conflicts in hilly merge/weave sections near interchanges
- Truck-involved crashes caused by lane changing and blind spots

Stakeholder Set Three Key Improvement Targets

Metrics	Targets
Improve Truck Travel Times	Reduce freight vehicles travel times by 17%
Reduce Number of Wasted Trips	Reduce the number of wasted trips by 15%
Improve truck safety	Reduce truck-related conflicts by 30%

Applications Considered for Improving Freight Reliability

V2I Safety

Red Light Violation Warning **Curve Speed Warning** Stop Sign Gap Assist Spot Weather Impact Warning Reduced Speed/Work Zone Warning Pedestrian in Signalized Crosswalk Warning (Transit)

V2V Safety

Emergency Electronic Brake Lights (EEBL) Forward Collision Warning (FCW) Intersection Movement Assist (IMA) Left Turn Assist (LTA) Blind Spot/Lane Change Warning (BSW/LCW) Do Not Pass Warning (DNPW) Vehicle Turning Right in Front of Bus Warning (Transit)

Road Weather

Motorist Advisories and Warnings (MAW) Enhanced MDSS Vehicle Data Translator (VDT) Weather Response Traffic Information (WxTINFO)

Environment

Eco-Approach and Departure at Signalized Intersections **Eco-Traffic Signal Timing Eco-Traffic Signal Priority** Connected Eco-Driving Wireless Inductive/Resonance Charging **Eco-Lanes Managemen**

Improve Reliability

Ico-Ramp Metering

Control

Low Emissions Zone Management AFV Charging / Fueling Information **Eco-Smart Parking**

Dynamic Eco-Routing (light vehicle, transit, freight)

Eco-ICM Decision Support System

Agency Data

Probe-based Pavement Maintenance Probe-enabled Traffic Monitoring Vehicle Classification-based Traffic **Studies** CV-enabled Turning Movement & Intersection Analysis CV-enabled Origin-Destination Studies Work Zone Traveler Information

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Freight-Specific Dynamic Travel Planning and Performance

Drayage Optimization

Smart Roadside

Wireless Inspection **Smart Truck Parking**



U.S. Department of Transportation ITS Joint Program Office

Applications Considered for Improving Truck Safety

V2I Safety

Red Light Violation Warning

Curve Speed Warning

Stop Sign Gap Assist

Spot Weather Impact Warning

Reduced Speed/Work Zone Warning

Pedestrian in Signalized Crosswalk Warning (Transit)

V2V Safety

Emergency Electronic Brake Lights (EEBL) Forward Collision Warning (FCW) Intersection Movement Assist (IMA) Left Turn Assist (LTA)

Blind Spot/Lane Change Warning (BSW/LCW)

Do Not Pass Warning (DNPW)

Vehicle Turning Right in Front of Bus Warning (Transit)

Road Weather

Motorist Advisories and Warnings (MAW)
Enhanced MDSS

Vehicle Data Translator (VDT)

Weather Response Traffic Information (WxTINFO)

Environment

Eco-Approach and Departure at Cignalized Intersections
Eco-Traffic Signal Timing

Eco-Con

Wire Improve Truck Safety

Eco Lanes Management
Eco Speed Harmonization

Eco-Cooperative Adaptive Cruise Control

Eco-Traveler Information

Eco-Kamp Metering

Low Envissions Zone Management

AFV Charging / Fueling Information

Eco-Smart Parking

rynamic Eco-Routing (light vehicle, transit, freight)

Eco-ICM Decision Support System

Agency Data

Probe-based Pavement Maintenance
Probe-enabled Traffic Monitoring
Vehicle Classification-based Traffic
Studies
CV-enabled Turning Movement &
Intersection Analysis
CV-enabled Origin-Destination Studies
Work Zone Traveler Information

Mobility

Advanced Traveler Information System Intelligent Traffic Signal System (I-SIG)

Signal Priority (transit, freight)

Mobile Accessible Pedestrian Signal System (PED-SIG)

Emergency Vehicle Preemption (PREEMPT)
Dynamic Speed Harmonization (SPD-HARM)

Queue Warning (Q-WARN)

ing

Cooperative Adaptive Cruise Control (CACC) Incident Scene Pre-Arrival Staging Guidance

for Emergency Responders (RESP-STG)
Incident Scene Work Zone Alerts for Drivers

and Workers (INC-ZONE)

Emergency Communications and Evacuation (EVAC)

Connection Protection (T-CONNECT)

Dynamic Transit Operations (T-DISP)

Dynamic Ridesharing (D-RIDE)

Freight-Specific Dynamic Travel Planning and Performance

Drayage Optimization

Smart Roadside

Wireless Inspection

Smart Truck Parking



U.S. Department of Transportation ITS Joint Program Office

Connected Vehicle Applications Selected in Performance-Driven Approach

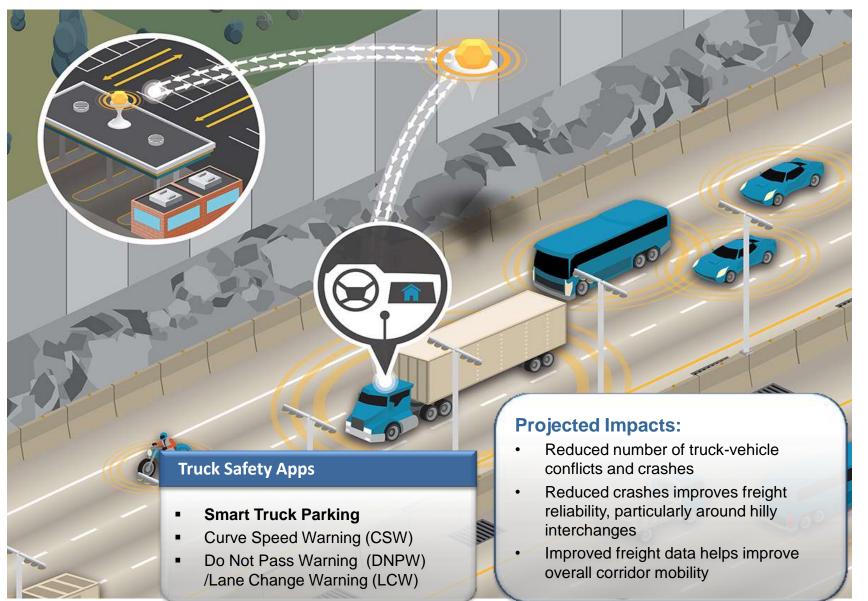
Improve Freight Productivity

- Freight Advanced Traveler Information System (FRATIS)
- Drayage Optimization (DRG-OPT)
- Freight Signal Priority (FSP)

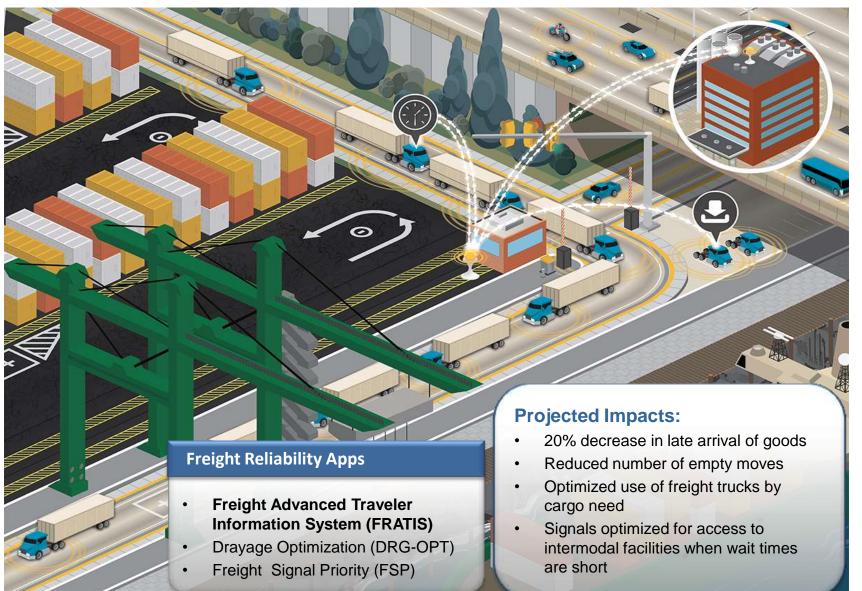
Improve Truck Safety

- Smart Truck Parking
- Curve Speed Warning (CSW)
- Do Not Pass Warning (DNPW) /Lane Change Warning (LCW)

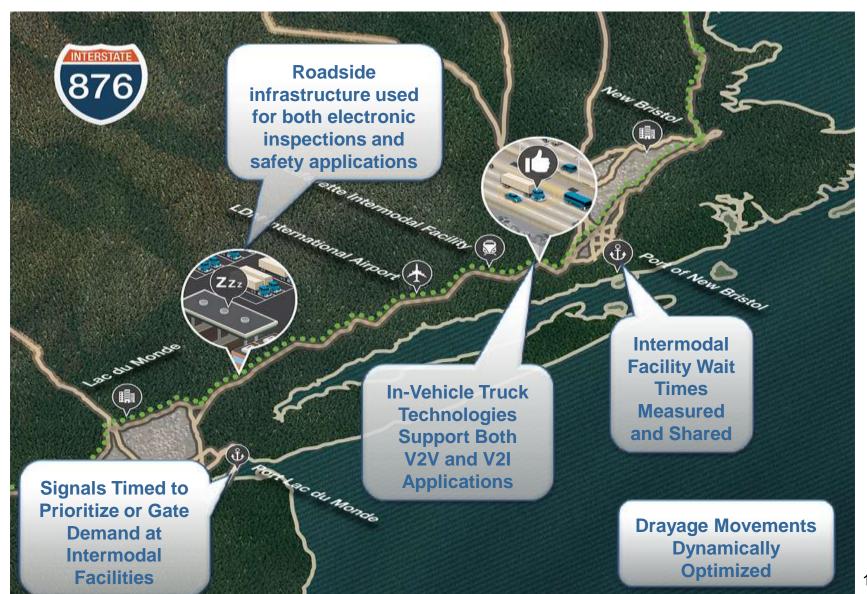
Projected Synergies and Impacts from Truck Safety Apps in the Deployment Concept



Projected Synergies and Impacts from Freight Reliability Applications in the Deployment Concept



Integrated Concept for I-876 Corridor



Stakeholder Q&A

Jeff Spencer (FTA)

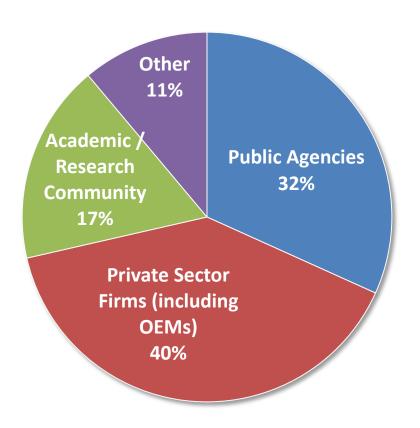
Connected Vehicle Pilot Deployment Program Request for Information (RFI) Update

Kate Hartman
USDOT Intelligent Transportation Systems
Program Manager, CV Pilot Deployment Program

Request for Information – Connected Vehicle Pilot Deployment Program

- On March 12, 2014, the United States Department of Transportation (USDOT) released a Request for Information (RFI) on the Federal Register for the Connected Vehicle Pilot Deployment Program.
- Input will be used to help refine plans for one or more pilot deployments.
- Pilot Deployments are expected to combine connected vehicle and mobile device technologies innovations to improve traveler mobility and system productivity, while reducing environmental impacts and enhancing safety.
- The Federal Highway Administration (FHWA) anticipates a procurement action for one or more pilot model deployment concepts in 2015.
- The due date for responses was April 11, 2014.

Connected Vehicle Pilot RFI Responses



The USDOT received 63 responses to the RFI

Category	Number of Responses
Public Agencies	20
Private Sector Firms	25
Academic / Research	11
Other	7
TOTAL	63

Connected Vehicle Pilot RFI Responses

Public Agencies

Arizona Department of Transportation and Maricopa County Department of Transportation • Arlington County Transit (VA) • Caltrans • City of Detroit • Colorado Department of Transportation • Contra Costa Transportation Authority • Florida Department of Transportation (2 responses) • Gateway Cities Council of Governments • Idaho Transportation Department • Los Angeles County Metropolitan Transportation Authority • Metra (Chicago) • Metropolitan Transportation Commission • Miami-Dade Expressway Authority • Michigan Department of Transportation • Minnesota Department of Transportation • Missouri Department of Transportation • North / West Passage Pooled Fund Program • Utah Department of Transportation • Virginia Department of Transportation

Private Sector Firms

Aldis · Arada Systems · Booz Allen Hamilton · Bosch · Codha Wireless · Continental Automotive Systems · CSS-Dynamac · Dering and Estrada · Ford Motor Company and Volkswagen Group of America · Indrasoft · Infineon Technologies · Intelligent Imaging Systems · Iteris · INRIX · Kapsch · Leidos · NextEnergy · Productivity Apex · Qualcomm · Sirius XM · Southwest Research Institute · Timmons Group · Verizon · Volvo Group · Weather Telematics

Connected Vehicle Pilot RFI Responses

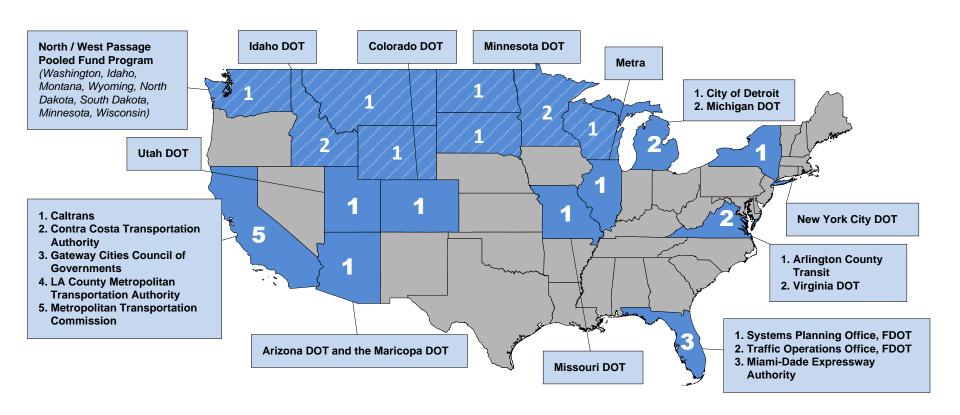
Academic / Research Community

California Partners for Advanced Transit and Highways (PATH) · Carnegie Mellon University · Idaho National Laboratory · La Trobe University (Australia) · University of California at Riverside · University of Michigan Transportation Research Institute (UMTRI) · University of Minnesota · Texas A&M Transportation Institute (TTI) · Virginia Tech Transportation Institute (VTTI) · Wayne State University

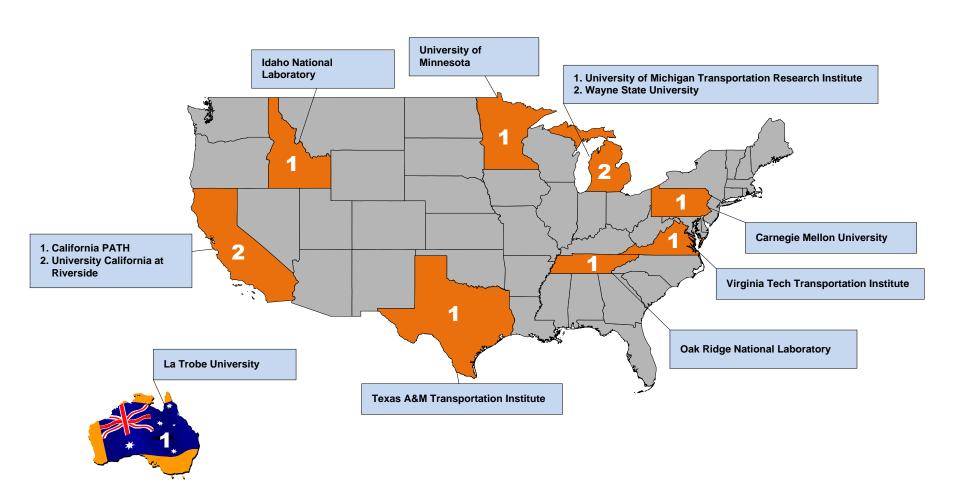
Others

American Trucking Association (ATA) • Intelligent Transportation Society of California (ITSCA) • The League of American Bicyclists • OmniAir • Prospect Silicon Valley • Ridesharing Institute

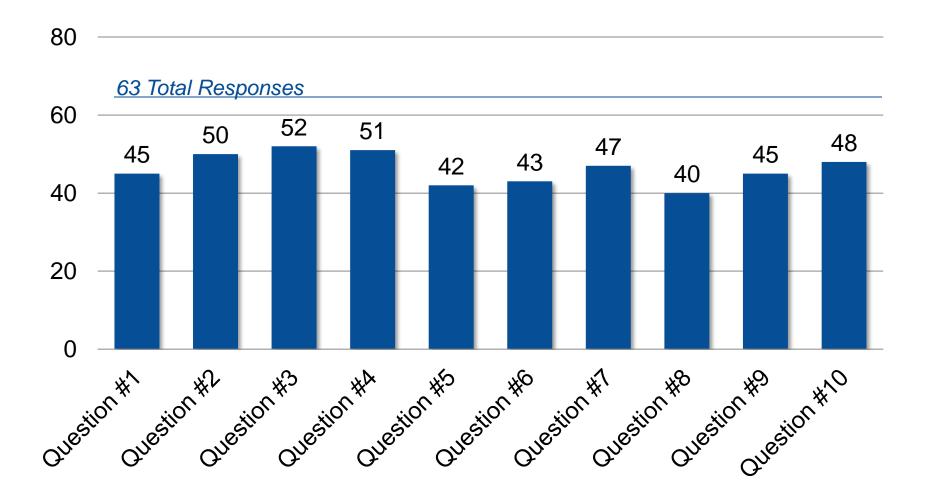
Connected Vehicle Pilot RFI Responses: Public Agencies



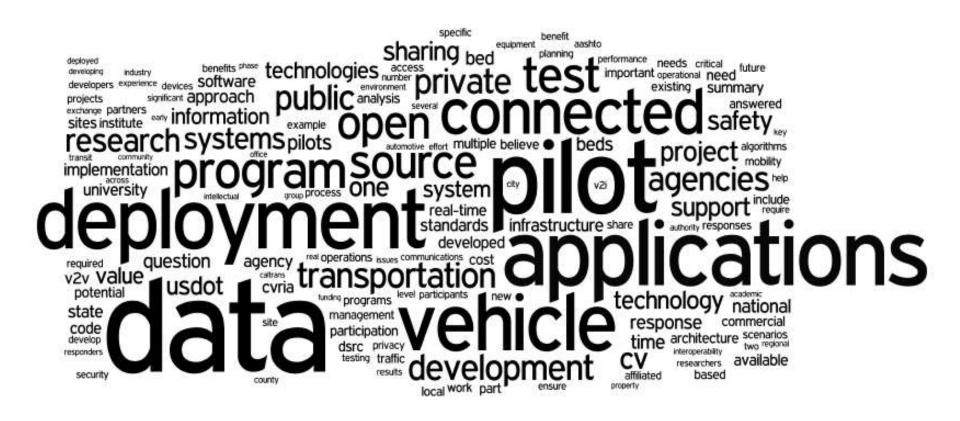
Connected Vehicle Pilot RFI Responses: Academic / Research Community



Number of Responses to RFI Questions



CV Pilot RFI Response Word Wall



Summary of Responses to RFI Questions Proposed Time Frame

Question 1: The DOT envisions an initial wave of pilot deployments to be awarded and commence in 2015. Additional waves may follow this first wave, through 2017. After a 12-18-month planning and deployment phase for each selected pilot site, a period of pilot operational testing and data collection is expected. The operational period, results analysis, and publication of final results are anticipated to occur over a period that does not exceed 18 months. Is this schedule too cautious, too ambitious, or about right?

- Most responders agreed that a 12-18 month planning and deployment phase for each selected pilot site (72%), and an 18 month operation, analysis, and publication of final results (66%) are reasonable.
- Eight responders recommended allowing more planning and deployment time.
- Nine responders recommended allowing more operation, analysis, and publication time.
- Few responders thought the schedule was too cautious based on their experiences or the expectation.

Summary of Responses to RFI Questions Number of Sites and Pilot Deployment Costs

Question 2: Is it feasible to achieve the goals of the program with multiple deployment sites? What is the rough order of magnitude of resources (e.g., cost, vehicles, roadside installations, devices, or size of geographic area) expected to enable a meaningful pilot deployment in a single site? What is an appropriate Federal/site cost share split?

- The majority of responders agreed that consideration should be given to multiple deployment sites.
- Only one responder recommended against multiple deployments citing potential limitations to resources.
- Some responders believe that multiple deployment sites should provide a wide diversity of applications, locations (including urban, suburban, and rural), weather, topological variations, products, jurisdictions, and road types.
- Rough order of magnitude costs for pilot deployments ranged from \$1 million to \$100 million.
- Most public agencies recommended 80/20 or 90/10 cost share split and also recommended including soft match.
- Some private sector firms and the academic/research community recommended 50/50 cost share split.

Summary of Responses to RFI Questions Data Sharing

Question 3: The DOT intends to provide open appropriate access to the data collected as part of this effort through the Real-Time Data Capture and Management Program. Appropriate access includes suitable protections regarding data ownership, intellectual property rights, and privacy.

- a. Do you see value in broadly sharing the data with other researchers?
- b. Will such data sharing inhibit participation in the pilot deployment program? If so, what mitigation actions will encourage participation?
- c. How should the Research Data Exchange be used in support of the pilot deployments? Should data be uploaded as the deployments are being conducted (i.e., real-time feeds) or as daily archives?
- a. Nearly all responders stated that there is value in sharing the data with other researchers.
- b. All of the broad classes of respondents agreed that data sharing is good and will not be an impediment to participation provided that:
 - PII is removed; Intellectual Property (IP) is protected
 - Proprietary and commercial data is removed;
 - The data sharing agreement is not too onerous; and
 - Research partners are connected with the data.
- c. Responses on the topic of daily uploads vs. real-time were mixed.

Summary of Responses to RFI Questions Open Source Development

Question 4: The DOT has identified an open source approach as a method to ensure sharing of Government-funded research products and shorten the time lag between research and deployment.

- a. Do you see value in making algorithms and application source code funded by this pilot deployment program broadly available?
- b. Will such an open source approach inhibit participation in the pilot deployment effort? If so, what mitigation actions will encourage participation?
- c. Should any particular type of application be provided in open source format (e.g., safety applications, non-safety applications, or mobility applications)?
- d. The DOT seeks to encourage commercially developed applications based on these pilot deployments. What other avenues do you see for rapid commercialization besides an open source approach?
- a. 71% of the responders agreed with the approach as a whole;
 18%responders agreed with the approach, but with reservations mostly having to do with IP rights and if the funding is government based; and 11% disagreed with the approach all together.
- b. Many of responders think that if IP rights can be protected this would encourage private companies to participate.

Summary of Responses to RFI Questions Open Source Applications (continued)

• c. Which Apps?

- Some responders believed that any application funded by the program should be Open Source.
- There were mixed responses about the Safety Applications with some responders believing they should NOT be open source because of security and other respondents believing they should be open source to foster research activities.
- Many responders believe security applications should not be Open Source, but one agency strongly believed they should be Open Source to avoid 'security through obscurity' problems.
- d. Path to Commercialization?
 - Many responders suggested the fastest way to commercialization is to have real-world pilot sites up and running to demonstrate the technology, benefits, and cost of the pilots.
 - A few responders suggested public/private partnerships as another method to faster commercialization with fund sharing.

Summary of Responses to RFI Questions CV Reference Implementation Architecture

Question 5: The DOT wants to use these pilot deployments to support early implementation of connected vehicle technology. Connected vehicle technology needs to be interoperable and, as a result, requires consistency across implementations. What is the role of the Connected Vehicle Reference Implementation Architecture?

- There was general consensus from responders that the CVRIA is a useful tool for identifying the key interfaces across the connected vehicle environment which will support further analysis to identify and prioritize standards development activities and support a national deployment of connected vehicle technologies.
- Several responders strongly encouraged the use of the CVRIA to support planning activities for the CV Pilots.
- Public agencies saw the potential for the CVRIA to support replication of work already done by the USDOT.
- Some private sector responders believed the architecture should define the interfaces to the vehicle via communication technologies and other backend data exchange requirements, but should not provide any in-vehicle architecture requirements.

Summary of Responses to RFI Questions Early V2V Applications

Question 6: How should the pilot programs be used to support early implementation of technologies enabling vehicle-to-vehicle applications?

- Many public agencies recommended that the pilots use public vehicle fleets (maintenance, emergency response, transit) possibly equipped with aftermarket devices, and involve commercial vehicles to accelerate deployment of V2V applications.
- Several public agencies, researchers and private sector firms emphasized the importance of working in partnership with vehicle manufacturers through consortia such as CAMP.
- Public agencies and academic researchers commented on the challenges of developing and testing the security certificate management system, ensuring interoperability of the applications, and concerns about developing common standards and architecture.
- Several of the private sector firms stated that testing and validation of the V2V applications should be the primary purpose of the pilots.

Summary of Responses to RFI Questions Affiliated Test Beds

Question 7: The DOT has invested in connected test bed development. What role should the affiliated connected vehicle test beds play in preparing or conducting pilot deployments?

- Some of the responders expressed their views on whether the applicants proposing pilots should be required to obtain affiliated connected vehicle test bed status or work with an existing test bed (affiliated or otherwise).
 - Five responders were opposed to requiring affiliated status.
 - Eleven responders supported the idea of the pilots expanding upon or working with an existing test bed.
- Some responders suggested other possible uses of the test beds:
 - Conducting simulations before deploying a full pilot;
 - Continuing testing and validating of standards;
 - Testing of alternative architectures;
 - Researching connected vehicle applications for vulnerable road users;
 - Conducting research into technologies such as vehicle automation,
 transportation cybersecurity, and "big data" for transportation; and
 - Forming the basis for a peer exchange or lessons learned program.

Summary of Responses to RFI Questions AASHTO Footprint Analysis

Question 8: The American Association of State Highway and Transportation Officials has prepared a connected vehicle footprint analysis. To what extent can deployment scenarios identified in that analysis be achieved as a part of a pilot deployment?

- Many responders believed that using the AASHTO analysis would be a good starting point for developing or selecting pilot deployments.
- Several respondents felt the AASHTO analysis might be too much to cover in the pilot deployments, but a diverse set of pilots covering as wide a range of the deployment scenarios as possible is recommended.
 - Some responders stated that a pilot deployment should not cover all applications, but focus on the most valuable "low hanging fruit".
 - Some responders stated that the value of the applications should be determined by the benefit to the real-world needs of the community.
- Public agencies responded favorably to the AASHTO analysis, but some agencies remarked that it focused primarily on DSRC applications.
- Some private sector firms stated that the lessons learned from the pilot deployments should be used to improve the AASHTO guidance.

Summary of Responses to RFI Questions Performance Measurement and Teaming

Question 9: How can the potential value of connected vehicle applications best be measured and estimated in concert with pilot deployment activities?

- All responders supported the use of performance measurements in pilot deployment activities, but suggest a broad range of criteria and/or methods.
- Some responders stated that they support a 'before and after' study.

Question 10: Based on the nature of the pilot deployments, DOT believes that a multimodal cooperative effort involving private and public sector organizations will be required. Feedback is requested on issues including the challenges in forming the teams as a lead organization, a partner, or another participant. What forms or demonstrations of commitment by the participants are reasonable and appropriate requirements of respondents to a solicitation for the pilot deployment program (e.g. letters of intent, proposed matching requirements, or draft project plans)?

 All responders indicated support for multi-modal cooperative teams involving public, private, and civic organizations with emphasis on publicprivate partnerships.

Key Takeaways

- The responses were overwhelmingly positive with regard to the idea of having CV Pilot Deployments.
- The idea of having multiple sites was broadly supported
- There do not seem to be any major red flags, although there needs to be a nuanced approach around key issues such as data sharing, privacy, and IP protection.
- The time frame for the pilots was considered to be generally practicable, although some respondents felt the time frame might be too ambitious.
- Security and credential management was brought up in several responses, although the RFI did not specifically ask a question about it.
- The costs estimated range wildly, from as little as \$1M to \$100M
- There appears to be a split between respondents who think of the CV Pilots as primarily non-DSRC and mobility/environmentally related, and those who consider the CV Pilots to be heavily DSRC-dependent and safety-focused.

Questions?